SeaWiFS

OPERATIONAL ARCHIVE PRODUCT SPECIFICATIONS

Version 4.0

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Change Log

(* indicates major/important modification.)

From Version 4.0 (3/00):

*. For all Level-2 and Level-3 data products:
   a. Replaced global attribute **Software ID** with **Software Name** and **Software Version.**
   b. Removed global attribute **Processing Log.**
   c. Added global attributes **Sensor Name** and **Input Parameters**.

*. For Level-2 GAC data products:
   a. * Removed geophysical parameter SDSs **La_670**, **La_865** and **CZCS_pigment**.
   b. * Added geophysical parameter SDSs **nLw_670** and **angstrom_510**.
   c. * Change data type for **l2_flags** from 2-byte to 4-byte integer; increased number of defined flags from 16 to 24; changed flag definitions (see Table 5).
   d. * Added Vgroup **Sensor Band Parameters**, consisting of new SDSs **wavelength**, **vcal_gain**, **vcal_offset**, **F0**, **k_oz** and **Tau_r**, and related global attributed **Number of Bands.**
   e. Added arrays of latitude and longitude control points, including global attributes **Number of Pixel Control Points** and **Number of Scan Control Points** and SDSs **cntl_pt_cols**, **cntl_pt_rows**, **longitude** and l**atitude**.
   f. Removed obsolete global attributes **NORAD Line 1**, **NORAD Line 2**, **Filled Scan Lines**, **FF Missing Frames** and **SDPS Missing Frames**.
   g. Removed SDSs **eng_qual**, **s_flags**, **l_vert**, **tilt_lats**, and **tilt_lons**; the VGroup **Converted Telemetry**, consisting of SDSs **inst_ana** and **inst_dis**; and the VGroup **Raw SeaStar Data**, consisting of SDSs **gain** and **tdi.**

*. For Level-2 Browse data products:
   a. Removed obsolete global attributes **NORAD Line 1**, **NORAD Line 2**, **Filled Scan Lines**, **FF Missing Frames** and **SDPS Missing Frames**.
   b. Removed SDSs **l_vert**, **tilt_lats**, and **tilt_lons**; the VGroup

*. For Level-3 binned data products:
   a. * Removed geophysical parameter Vdatas **La_670** and **CZCS_pigment**.
   b. * Added geophysical parameter Vdatas **nLw_670** and **angstrom_510**.
   c. Added global attribute **Units**, specifying units of geophysical parameters.
   d. Removed global attributes **L2 flag Usage** and **L2 Engineering Quality Usage**.

*. For Level-3 standard mapped image data products:
   a. * Removed SMI product for **CZCS_pigment**.
   b. * Added SMI product for **angstrom_510**.
   c. Removed global attributes **L2 flag Usage** and **L2 Engineering Quality Usage**.

From Version 3.0 (11/96):

*. For NRT ancillary products:
   a. Naming Convention: Replaced NMC with NCEP as a source of meteorological data.
   b. For global attributes **Data Source** and **Data Source Desc**, replaced NMC with NCEP as a source of meteorological data.
   c. For global attribute **Latitude Step**, changed value for meteorological data from 2.5 to 1.0.

d. For global attribute **Longitude Step**, changed value for meteorological data from 2.5 to 1.0.
e. For global attribute **SW Point Longitude**, changed value for meteorological data from -178.75 to -180.0.
f. For global attribute **Number of Rows**, changed value for meteorological data from from 73 to 181.
g. For global attribute **Number of Columns**, changed value for meteorological data from from 144 to 360.
h. For global attribute **Temporal Resolution**, changed NMC reference to NCEP for meteorological data.
i. Specified that for all SDSs, the first point in each array is the northwesternmost point of each grid.
j. For SDSs **z_wind**, **z_wind_QC**, **m_wind**, and **m_wind_QC**, added "at 10 m" to **long_name** description.
k. For SDSs **press** and **press_QC**, added "at mean sea level" to **long_name** description.
l. * Added SDSs **rel_hum** and **rel_hum_QC**.
m. Product Size: Changed size estimate for meteorological data products.
n. Modified figure to reflect SDS changes.

*. For climatological ancillary products:
a. Introduction: Changed descreption of meteorological climatology to indicate five parameters instead of four.
b. Naming Convention: Changed name of meteorological climatology file.
c. For global attributes **Data Source** and **Data Source Desc**, added GEOS-1 for meteorological data.
d. For global attribute **Replacement Flag**, changed "ORIGINAL" to name of previous climatology for meteorological data.
e. Added global attributes **Start Month** and **End Month**.
f. For global attribute **Longitude Step**, changed value for meteorological data from 2.0 to 2.5.
g. For global attribute **SW Point Latitude**, changed value for meteorological data from -89.0 to -90.0.
h. For global attribute **SW Point Longitude**, changed value for meteorological data from -179.0 to -180.0.
i. For global attribute **Number of Rows**, changed value for meteorological data from from 90 to 91.
j. For global attribute **Number of Columns**, changed value for meteorological data from from 180 to 144.
k. Specified that for all SDSs, the first point in each array is the northwesternmost point of each grid.
l. For SDSs **z_wind_mean**, **z_wind_std_dev**, **z_wind_obs**, **m_wind_mean**, **m_wind_std_dev**, and **m_wind_obs**, added "at 1000 mb" to **long_name** description.
m. For SDSs **press_mean, press_std_dev**, and **press_obs**, added "at mean sea level" to **long_name** description.
n. * Added SDSs **p_water_mean**, **p_water_std_dev**, and **p_water_obs**.
o. Product Size: Changed size estimate for meteorological climatology.
p. Modified figure to reflect SDS changes.

From Version 2.8 (10/95):

1. For Level-1A data products:
   a. For Calibration Vgroup, specified that the calibration data are those obtained for the first scan line of the product.
   b. * Removed SDS **time_factor** from the Calibration Vgroup.
   c. * Added SDSs **ref_year**, **ref_day**, **ref_minute**, **t_const**, **t_linear**, **t_quadratic**, and **cal_offs** to the Calibration Vgroup.
   d. Clarified definitions of SDSs **entry_year** and **entry_day** in the Calibration Vgroup.
   e. Modified figure to indicate changes in the SDSs list of the Calibration Vgroup.
2. For all occurrences of global attribute **Processing Control** and **Processing Log**, specified that vertical bar or carriage return characters serve as delimiters.
3. For all occurrences of global attribute **Processing Log**, clarified definition to limit content to "important" information (i.e., exclude routine status and diagnostic information).
4. * For Level-1A browse products, specified that raster **brs_data** value 255 indicates missing bands.
5. For Level-1A data, Level-1A browse, Level-2 GAC data, and Level-2 browse products:
   a. Clarified explanation for global attribute **Orbit Node Longitude**.
   b. Specified order of matrix for Navigation Vgroup SDS **sen_mat**.
   c. Clarified explanation of SDS **nflag** in Navigation Vgroup.
6. For Level-2 GAC data products:
   a. Specified that Level-1A GAC file name must be listed first in global attribute **Input Files**.
   b. Removed global attributes **Calibration Entry Year** and **Calibration Entry Day**.
   c. * Added Calibration Vgroup.
   d. Modified figure to add the Calibration Vgroup.
7. For Level-2 browse products:
   a. Removed extra **px_ll_last** SDS from figure.
   b. * Changed Level-2 data byte values from 1-250 to 0-250 for global attributes **Base**, **Slope**, and **Intercept**.
   c. * For raster **brs_data**, explained priority of special values and changed what each special value indicates, with all values being used now, including 255 for missing bands.
8. * For Level-3 binned products, modified description of the **_sum** and **_sum_sq** fields for the subordiante files to indicate that the accumulation is done on the binned values, not their natural logs.
9. * For Level-3 SMI products:
   a. Removed reference to use of maximum likelihood estimator (MLE).
   b. For SDS **l3m_data**, specified that value 255 indicates no data from parent binned product.
   c. Modified table to indicate that 255 is special value, added scaling column, removed storage column, and expanded caption.
10. * For Level-3 browse products' raster **brs_data**, explained priority of special values and changed what each special value indicates, with all values being used now, including 255 for no data.
11. For NRT ancillary products:
    a. Introduction: Clarified time representation of ozone data. Added reference to table of Q/C codes.
    b. Naming Convention: Added ADEOS as possible source of ozone data. Modified names for EP TOMS data. Explained TOMS time range.

c. For global attributes **Data Source**, **Data Source Desc**, **Satellite Platform**, and **Temporal Resolution**, accounted for possible ozone data from ADEOS.
d. For global attributes **Data Source** and **Satellite Platform**, modified value for EP TOMS data.
e. Specified that file names stored in **Input Files** be without path and indicated that there may be more than one input file name.
f. Modified definitions of global attributes **Start Time**, **End Time**, **Start Year**, **Start Day**, **Start Millisec**, **End Year**, **End Day**, and **End Millisec** to show dependency on global attribute **Data Type**. Now, these attributes also reflect time ranges for TOMS data.
g. Added global attribute **Node Crossing Time**.
h. Clarified explanation for global attribute **Points Modified**.
i. * Removed SDSs **rel_hum** and **rel_hum_QC**.
j. Modified explanations of **z_wind_QC**, **m_wind_QC**, **press_QC**, and **ozone_QC** to reference table of Q/C codes and define the primary input product.
k. * Added SDSs **p_water** and **p_water_QC**.
l. Modified explanation **ozone_QC** to indicate that TOVS gridding is not considered a change for the purpose of the Q/C flag.
m. Added table of Q/C codes representing modifications made to original ancillary data.
n. In figure, replaced "rel_hum" and "rel_hum_QC" labels with "p_water" and "p_water_QC", respectively.

12. For the sensor calibration table:
a. Modified Naming Convention section, and global attributes **Product Name** and **Replacement Flag**, to reflect change in the file name of the sensor calibration table from SEAWIFS_CAL.TBL to SEAWIFS_SENSOR_CAL.TBL.
b. Added global attributes **Reference Year**, **Reference Day**, and **Reference Minute**.
c. * Removed **time_factor** as a field in **BxParms** Vdata.
d. * Added **t_const**, **t_linear**, **t_quadratic**, and **cal_offs** as fields in **BxParms** Vdata.
e. Modified figure to indicate increased number of fields (10 instead of 7) for **BxParms** Vdata.

From Version 2.7.1:

1. For Level-1A data, Level-1A browse, Level-2 GAC data, and Level-2 browse products, added global attributes **Start Node**, **End Node**, **Start Center Latitude**, **Start Center Longitude**, **End Center Latitude**, and **End Center Longitude**.
2. For Level-1A data products, added "IGC" as a data type. Modified Introduction and Naming Convention sections and definition of global attribute **Data Type**.
3. For all browse data products, added global attribute **Legend**.
4. For Level-2 GAC data products:
a. Changed delimiters in global attributes **Input Files**.
b. Defined "first bit" in explanation of **l2_flags** SDS; added new reference for STRAYLIGHT1 algorithm.
c. Added global attribute **Mask Names**.
d. Modified definitions of SDSs in Geophysical Data Vgroup and modified Table 2 to indicate that alternate values (Level-1A counts when mask bit is set) are not scaled.

e. Changed name of SDS in Geophysical Data Vgroup from **eps_68** to **eps_78**. Modified its definition, Table 2, and Figure 5 accordingly.

5. For Level-2 browse products:
   a. Changed delimiters in global attributes **Parent Input Files**.
   b. Modified definitions of global attributes **Base**, **Slope**, and **Intercept** to indicate gray-level range as being 1 to 250.
6. For Level-2 and Level-3 browse products, modified definitions of global attributes **Base**, **Slope**, and **Intercept**, and of raster **brs_image**, to described reserved gray levels 251 to 255.
7. For Level-3 binned data products:
   a. Changed delimiters in global attributes **Input Files** and **L2 Flag Names**.
   b. Modified definition of **sel_cat** in Vdata **BinList** to indicate that it is not used.
   c. Modified definition of **time_rec** in Vdata **BinList** to clarify meaning of "first bit" and representation of bits in **time_rec**.
   d. Added global attributes **Northernmost Latitude**, **Southernmost Latitude**, **Westernmost Longitude**, and **Easternmost Longitude**.
   e. Modified definition of global attributes **Period Start Year**, **Period Start Day**, **Period End Year**, and **Period End Day** to clarify their use with **time_rec**.
   f. Added reference to data day definition in introduction.
   g. Changed name of Vdata in "Level-3 Binned Data" Vgroup from **eps_68** to **eps_78**. Changed Figure 7 accordingly.
8. For Level-3 binned, SMI, and browse products, added **Orbit**, **Start Orbit**, and **End Orbit** as a global attributes.
9. For Level-3 SMI products, added global attribute **L2 Flag Names**.
10. For Level-3 SMI products and NRT and climatological ancillary products, added **SW Point Latitude** and **SW Point Longitude** as global attributes.
11. For NRT ancillary products:
    a. Changed introduction to explain Q/C code.
    b. Modified the Naming Convention section to account for new TOVS data product names.
    c. Changed definition of global attribute **Temporal Resolution**.
    d. Added global attribute **Points Modified**.
    e. Modified definitions of global attributes **Start Time**, **End Time**, **Start Year**, **Start Day**, **Start Millisec**, **End Year**, **End Day**, and **End Millisec** for TOVS data.
    f. Expanded definitions of _**QC** SDSs in Vgroup **Geophysical Data**.

From Version 2.7 (5/95):

1. Modified number-of-file and volume calculations for Level-1A GAC and GAC browse and Level-2 GAC and browse products to reflect one scene per orbit.
3. For Level-3 binned data products, added global attribute **L2 Flag Names**.
4. For NRT ancillary data, corrected typo in description of global attribute **Data Source Desc**.

From Version 2.6:

1. In introduction to Level-1A data products, changed definition of GAC scene to be a full swath.
2. For Level-1A data and Level-2 GAC data, clarified definition of **tilt**.
3. For each browse product, removed **palette** as a separate object and added a palette associated to the raster image; modified figures accordingly.

4. For all occurrences of global attribute **FF Missing Frames**, clarified definition.
5. For Level-1A and Level-2 browse products:
   a. * Added Navigation Vgroup.
   b. * Combined tilt SDSs into Sensor Tilt Vgroup for consistency with parent products; added **ntilts** to that Vgroup; removed **Number of Tilts** as a global attribute.
   c. Modified figures accordingly.
6. For Level-3 binned data:
   a. Changed data type of **radius**.
   b. Changed data type and contents of global attribute **L2 Flag Usage**; in introduction section, modified explanation of the use of **l2_flags**.
   c. In Vdata **BinIndex**, changed definition of **begin** field and added **start_num** field.
   d. In Vdata **BinList**, added **flags_set** field; modified figure and volume calculations accordingly.
7. For Level-3 SMI products:
   a. Changed data type and contents of global attribute **L2 Flag Usage**.
8. * Added specifications for NRT ancillary data products.
9. * Added specifications for climatological ancillary data products.

From Version 2.5:

1. For all occurrences of global attributes **SDPS Missing Frames**, clarified definition.
2. For Level-1A and Level-2 data:
   a. removed data type from global attribute **Title**;
   b. added SDS **csol_z** to Scan-Line Attributes Vgroup.
3. For all Level-1A and Level-2 data and browse products, added global attribute **Scene Center Solar Zenith**.
4. For Level-1A data, added SDSs **entry_year** and **entry_day** to Calibration Vgroup.
5. For Level-1A browse and Level-2 browse tilt information, references to **ntilts** were changed to **Number of Tilts**.
6. For Level-2 data:
   a. changed name of SDS **epsilon** to **eps_68** and the definition of its **long_name**;
   b. added global attributes **Calibration Entry Year** and **Calibration Entry Day**.
7. For Level-3 binned data:
   a. added global attributes **L2 Flag Usage** and **L2 Engineering Quality Usage**;
   b. changed name of Vdata **epsilon** to **eps_68**;
   c. added field **sel_cat** to Vdata **BinList**.
8. For Level-3 SMI and browse products:
   a. added global attribute **Measure**;
   b. corrected value of **Map Projection**.
9. For Level-3 SMI products:
   a. added global attributes **L2 Flag Usage**, **L2 Engineering Quality Usage**, **Data Minimum**, and **Data Maximum**.
10. Updated tables and figures as needed and made numerous editing changes.

From Version 2.4:

1. For all occurrences of global attributes **Input Files** and **Parent Input Files**, specified that the delimiter for file names is one blank space.
2. For all occurrences of global attribute **Processing Log**, specified that each will contain processing status, if any.

3. For all occurrences of global attribute **Sensor Characteristics**, modified definition of the content and added clarification of content. Contents of all **Sensor Characteristics** global attributes are now the same.
4. All Level-1A and Level-2 data products: Clarified explanations of **eng_qual**, **inst_ana**, ans **inst_dis**.

From Version 2.3:

1. Modified calculations of data product totals and volumes.
2. All products: Specified that file names stored in **Input Files** be without path.
3. All Level-1A and Level-2 data: Changed array sizes of **tilt_flags**, **tilt_ranges**, **tilt_lats**, and **tilt_lons** from the variable **ntilts** to the constant 20. **ntilts** refers to the number of valid values in those arrays.
4. All browse products: Added **Latitude Units** and **Longitude Units** as global attributes to all browse products. Removed **Parent Product Name** (redundant with **Input Files**).
5. Level-1A browse: ***** Added specifications for NOAA HRPT data. Changed content description of **Sensor Characteristics** to account for HRPT data.
6. Level-2 GAC data: Added definition of bit 16 in **l2_flags**.
7. Level-3 browse: Corrected naming convention examples. Changed second **Input Files** to **Parent Input Files** (what it was supposed to be).
8. ***** Added the sensor calibration table specifications.

From Version 2.2 (4 Nov 94):

1. Added product and processing flow diagrams.
2. Added description of the physical header block in subordinate files of Level-3 binned data products.

From Version 2.1 (21 Oct 94):

1. Level-1A data: ***** Added specifications for NOAA HRPT data; changed **Station Name** for GSFC HRPT data.
2. Level-1A browse: Changed pixel and scan subsampling rates for HRPT browse products to 8 so as to have equivalent resolution of GAC browse products; corrected **LAC Pixel Start Number** to be 147 for GAC data type.

From Version 2.0 (20 Oct 94):

1. Level-1A data: Changed **Data Type** character string for lunar and solar calibration data.
2. Modified calculations of data product totals and volumes.
3. Added the global attribute **Parent Input Files** to all browse products.
3. Level-1A browse: ***** Added specifications for browse products from GAC data.
4. Level-2 browse: Corrected definition of **Input Files** to remove ancillary data files.

From Version 1.0 (22 Jul 1994 draft):

1. ***** Added specifications for the Level-1A HRPT browse product.
2. Added **fxx_name**, where xx is the bit number of **l2_flags**, as attributes to **l2_flags** in the Level-2 GAC product specifications.
3. ***** Added specifications for the Level-3 browse product.
4. Began the near real-time ancillary data product specifications.
5. Made several modifications to tables and figures.
6. Made several minor corrections to text.

TABLE OF CONTENTS

1.0 Introduction

This document describes the specifications of SeaWiFS archive products (Figure &) which will be distributed by (available to users via) the NASA Goddard Space Flight Center's Distributed Active Archive Center (DAAC; Figure &). A summary of product volumes is given in Table &. The products are implemented in the Hierarchical Data Format (HDF) and HDF terminology is used in this document. For additional information on HDF, see Reference &.

It is important to understand that these specifications are given in terms of the logical implementation of the products in HDF and are not a physical description of file contents. The same data object may exist in different relative locations for two product files that are still within that product's specifications. Therefore, HDF software must be used to create or read these products.

The advantages of a logical implementation are that it facilitates platform independence, does not require that the application programmer have knowledge of the physical representation, and allows much greater flexibility for product generation. For example, data objects may be added or deleted without impacting other data objects in the same product. Indeed, *addition* of data objects not described in this document does alter a product's adherence to the specifications. In fact, HDF itself may create numerous other data objects within HDF files as a result of "bookkeeping" requirements. The use of HDF tools such as Vshow will display those additional objects along with the specified objects. These bookkeeping data should not be confused with the specified data objects.

Finally, it should also be noted that the order in which objects are presented in this document has no bearing on the specifications. The order was determined solely on the basis of a logical organization of the data objects for presentation purposes.

Figure 1. Flow diagram showing relationships of SeaWiFS operational archive products (bold) through their processing levels.

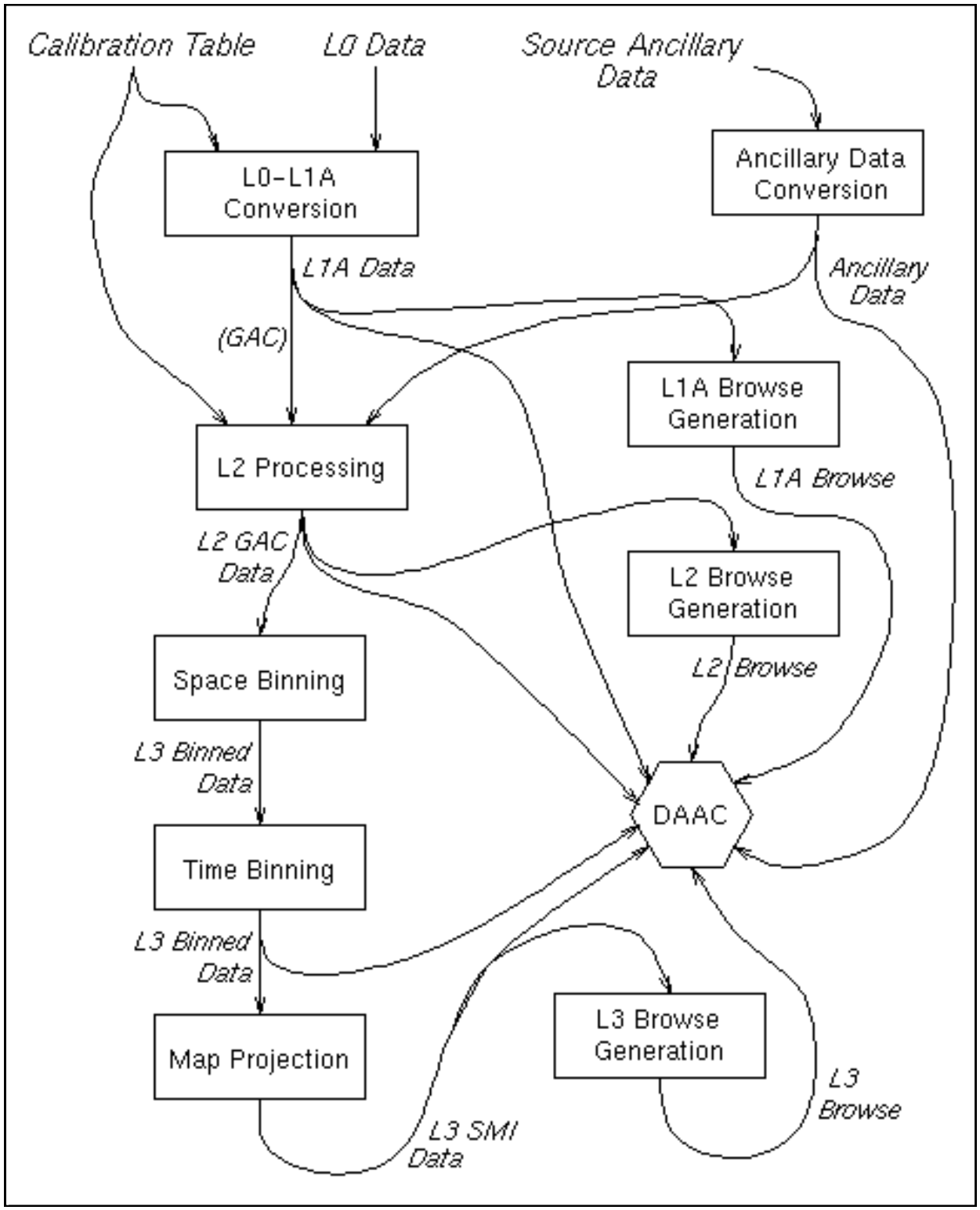

Figure 2. Diagram showing data flow of SeaWiFS operational archive products through major processing steps before delivery to the GSFC DAAC.

Table 1. Summary of SeaWiFS archive data product volumes. See text for assumptions used in the calculations.

2.0 Level-1A Data Products

2.1 Introduction

A SeaWiFS Level-1A product (see Figure &) is generated from Level-0 data files (see Appendix &). It contains all the Level-0 data (raw radiance counts from all bands as well as spacecraft and instrument telemetry), appended calibration and navigation data, and instrument and selected spacecraft telemetry that are reformatted and also appended. This product is stored as one physical HDF file.

Each product contains one type of Level-1A data. The type of the data is specified by the global attribute **Data Type**. The possible **Data Type** values are "GAC" for global-area coverage data, "LAC" for local-area coverage data, "LUN" for lunar calibration data, "SOL" for solar calibration data, "TDI" for data from a TDI check, "IGC" for data from an intergain calibration check, and "HRPT" for direct-readout data. (The generic term "LAC" is also used to refer to all full-resolution, recorded data, including lunar, solar, TDI, and IGC data.)

Note that GAC data are subsampled from full-resolution data with every fourth pixel of a scan line (from LAC pixels 147 to 1135) and every fourth scan line being recorded. Thus, GAC data are comprised of 248 pixels per scan line, whereas all other types are comprised of 1,285 pixels per scan line. Also note that HRPT data are collected at one of many HRPT stations (global attribute, **Station Name**), whereas all other data types are from dumps of the onboard flight data recorder. A catalog of all available HRPT stations is maintained on the SeaWiFS home page at http://seawifs.gsfc.nasa.gov/SEAWIFS/HRPT/HRPT_LOCATIONS.html.

For GAC data, individual products are generated from each Level-0 GAC recording period (the Earth data collection portion of an orbit). Each such GAC product thus constitutes one scene.

For HRPT data, each scene is comprised of one satellite pass. For recorded, full-resolution (e.g., LAC) data, each scene is comprised of a continuous recording of one data type.

2.2 Naming Convention

The form of a non-HRPT Level-1A file name is Syyyydddhhmmss.L1A_ttt, where S is for SeaWiFS, yyyydddhhmmss are the concatenated digits for the GMT year, day of the year, hours, minutes, and seconds of the first scan line, and ttt is a three-character data type code. For HRPT data, the form is Syyyydddhhmmss.L1A_Hhhh, where hhh is a three-character code identifying the agency and location of the HRPT station. Examples of file names for each Level-1A data type are (note that the times in file names of real data for all these types would, of course, not be the same):

S1996121130809.L1A_GAC for GAC data
S1996121130809.L1A_LAC for LAC data
S1996121130809.L1A_SOL for solar calibration data
S1996121130809.L1A_LUN for lunar calibration data
S1996121130809.L1A_TDI for TDI check
S1996121130809.L1A_IGC for intergain calibration check

S1996121130809.L1A_HNSG for NASA/GSFC HRPT data
(**Station Name** = "GSFC HRPT, NASA, MD")

2.3 Global Attributes

For global attributes that have constant values specific to this product type, the actual value is given.

2.3.1 Mission and Documentation

Product Name (character): the name of the product file (without path).

Title (character): "SeaWiFS Level-1A Data".

Data Center (character): for **Station Name** = "Wallops Flight Facility" or "GSFC HRPT, NASA, MD", "NASA/GSFC SeaWiFS Data Processing Center"; for all other HRPT stations, will be the same as **Station Name**.

Station Name (character): for all recorded data (GAC, LAC, SOL, LUN, TDI, IGC), "Wallops Flight Facility"; for HRPT stations, the station affiliation given on the web site.

Station Latitude (4-byte real): for **Station Name** = "Wallops Flight Facility", 37.9272; for **Station Name** = "GSFC HRPT, NASA, MD", 38.9958; for all other HRPT stations, the station latitude is given on the web site.

Station Longitude (4-byte real): for **Station Name** = "Wallops Flight Facility", -75.4753; for **Station Name** = "GSFC HRPT, NASA, MD", -76.8511; for all other HRPT stations, the station latitude is given on the web site.

Mission (character): "SeaStar SeaWiFS".

Mission Characteristics (character): "Nominal orbit: inclination = 98.2 (Sun-synchronous); node = 12 noon local (descending); eccentricity = <0.002; altitude = 705 km; ground speed = 6.75 km/sec".

Sensor (character): "Sea-viewing Wide Field-of-view Sensor (SeaWiFS)".

Sensor Characteristics (character): "Number of bands = 8; number of active bands = 8; wavelengths per band (nm) = 412, 443, 490, 510, 555, 670, 765, 865; bits per pixel = 10; instantaneous field-of-view = 1.5835 mrad; pixels per scan = 1285; scan rate = 6/sec; sample rate = 7710/sec". Note: Pixels per scan, scan rate, and sample rate are given for the sensor; effective rates for GAC data are lower due to subsampling.

Data Type (character): "GAC", "LAC", "LUN", "SOL", "TDI", "IGC", or "HRPT".

Replacement Flag (character): "ORIGINAL" if this is the first version of this product delivered to the DAAC; otherwise, it is set to the name of the product to be replaced (superseded) by the present product.

Software ID (character): identifies version of the operational software used to create this product.

Processing Time (character): local time of generation of this product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Input Files (character): the name of the Level-0 file (without path) from which the current product was created. This information is simply stored in the product as part of its processing history.

Processing Control (character): all input and processing control parameters used by the calling program to generate the product. Vertical bars or carriage return characters serve as parameter information delimiters. This information is simply stored in the product as part of its processing history.

Processing Log (character): not used.

2.3.2 Data Time

Start Time (character): start GMT of the first scan line of the scene; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

End Time (character): start GMT of the last scan line of the scene; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Scene Center Time (character): start GMT of the center scan line of the scene; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Node Crossing Time (character): GMT of descending node crossing; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Start Year (2-byte integer): GMT year of first scan line of the scene.

Start Day (2-byte integer): GMT day-of-year of first scan line of the scene.

Start Millisec (4-byte integer): GMT milliseconds-of-day of start of the first scan line of the scene.

End Year (2-byte integer): GMT year of last scan line of the scene.

End Day (2-byte integer): GMT day-of-year of last scan line of the scene.

End Millisec (4-byte integer): GMT milliseconds-of-day of start of the last scan line of the scene.

Start Node (character): "Ascending" or "Descending"; describes node direction at the start of the scene.

End Node (character): "Ascending" or "Descending"; describes node direction at the end of the scene.

Orbit Number (4-byte integer): orbit number of the scene.

NORAD Line 1 (character): not used.

NORAD Line 2 (character): not used.

2.3.3 Data Quality

Pixels per Scan Line (4-byte integer): 248 if **Data Type** = "GAC", else, 1285.

Number of Scan Lines (4-byte integer): number of scan lines in the scene.

LAC Pixel Start Number (4-byte integer): the LAC pixel number corresponding to the first pixel in scan lines of this product; 147 if **Data Type** = "GAC", else, 1.

LAC Pixel Subsampling (4-byte integer): the subsampling rate for the pixels in this product relative to LAC scan lines; 4 if **Data Type** = "GAC", else, 1.

Scene Center Scan Line (4-byte integer): number of the center scan line (1-relative) of the scene, relative to first scan line.

Filled Scan Lines (4-byte integer): not used.

FF Missing Frames (4-byte integer): frame formatter missing frames count for the Level-0 source file.

SDPS Missing Frames (4-byte integer): not used.

2.3.4 File Metrics

Gain 1 Saturated Pixels (4-byte integer, array size 8): number of saturated pixels for Earth gain 1 for each band.

Gain 2 Saturated Pixels (4-byte integer, array size 8): number of saturated pixels for Earth gain 2 for each band.

Gain 1 Non-Saturated Pixels (4-byte integer, array size 8): number of pixels not saturated for gain 1 for each band.

Gain 2 Non-Saturated Pixels (4-byte integer, array size 8): number of pixels not saturated for gain 2 for each band.

Zero Pixels (4-byte integer, array size 8): number of pixels, for each band, with value of 2 or less after subtraction of corresponding **dark_rest**.

Mean Gain 1 Radiance (4-byte real, array size 8): average radiance counts for pixels of gain 1 for each band.

Mean Gain 2 Radiance (4-byte real, array size 8): average radiance counts for pixels of gain 2 for each band.

2.3.5 Scene Coordinates

Latitude Units (character): "degrees North"; units used for all latitude values in this product.

Longitude Units (character): "degrees East"; units used for all longitude values in this product.

Scene Center Latitude (4-byte real): latitude of the nadir point of the scene's center scan line.

Scene Center Longitude (4-byte real): longitude of the nadir point of the scene's center scan line.

Scene Center Solar Zenith (4-byte real): solar zenith angle of the nadir point of the scene's center scan line.

Upper Left Latitude (4-byte real): latitude of the upper left scene corner.

Upper Left Longitude (4-byte real): longitude of the upper left scene corner.

Upper Right Latitude (4-byte real): latitude of the upper right scene corner.

Upper Right Longitude (4-byte real): longitude of the upper right scene corner.

Lower Left Latitude (4-byte real): latitude of the lower left scene corner.

Lower Left Longitude (4-byte real): longitude of the lower left scene corner.

Lower Right Latitude (4-byte real): latitude of the lower right scene corner.

Lower Right Longitude (4-byte real): longitude of the lower right scene corner.

Northernmost Latitude (4-byte real): northernmost latitude of all scan line end points.

Southernmost Latitude (4-byte real): southernmost latitude of all scan line end points.

Westernmost Longitude (4-byte real): westernmost longitude of all scan line end points.

Easternmost Longitude (4-byte real): easternmost longitude of all scan line end points.

Start Center Latitude (4-byte real): latitude of center pixel for first scan line.

Start Center Longitude (4-byte real): longitude of center pixel for first scan line.

End Center Latitude (4-byte real): latitude of center pixel for last scan line.

End Center Longitude (4-byte real): longitude of center pixel for last scan line.

Orbit Node Longitude (4-byte real): longitude of scene's orbit descending node (longitude at equatorial crossing of day-side node).

2.4 Vgroups

Of the following six Vgroups, four Vgroups, Scan-Line Attributes, Raw SeaStar Data, Converted Telemetry, and Navigation, contain data that are functions of scan lines. That is, each data object within these Vgroups have data for each scan line and is therefore dimensioned by the value of the global attribute, **Number of Scan Lines**. Thus, to get all the data corresponding to a specific scan line, n, the n^{th} values of all data objects in these four Vgroups would need to be read.

2.4.1 Scan-Line Attributes

The following data objects are SDSes belonging to the Vgroup "Scan-Line Attributes". Attributes of the SDSs are shown in **bold**.

msec (4-byte integer, array size **Number of Scan Lines**): **long_name** = "Scan-line time, milliseconds of day"; **valid_range** = (0,86399999); **units** = "milliseconds".

eng_qual (byte, array size **Number of Scan Lines** x 4): **long_name** = "Engineering data-out-of-range flags"; set bits indicate instrument analog telemetry values out of range; see Table 1.

s_flags (byte, array size **Number of Scan Lines** x 4): **long_name** = "Scan-line quality flags";
byte 1: sum of frame formatter bit error count and SDPS bit errors detected in this scan line;
byte 2: corrupted telemetry flag; set if bit errors were detected for this scan line and this is the first minor frame (containing ACS and GPS telemetry) in the major frame;
byte 3: for GAC data, the number (1 to 15) of the GAC line within the major frame;
byte 4: number of synchronization bits used for the bit error count divided by 5; taken from the first two bytes of Level-0 record.

s_satp (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Number of saturated pixels per band".

s_zerop (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Number of zero pixels per band".

slat (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan start-pixel latitude"; **valid_range** = (-90.,90.).

slon (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan start-pixel longitude"; **valid_range** = (-180.,180.).

clat (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan center-pixel latitude"; **valid_range** = (-90.,90.).

clon (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan center-pixel longitude"; **valid_range** = (-180.,180.).

elat (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan end-pixel latitude"; **valid_range** = (-90.,90.).

elon (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan end-pixel longitude"; **valid_range** = (-180.,180.).

csol_z (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan center-pixel solar zenith angle"; **valid_range** = (0.,180.).

tilt (4-byte real, array size **Number of Scan Lines**): **long_name** = "Tilt angle for scan line"; **valid_range** = (-20.1,20.1); positive values indicate aft tilts and negative values indicate forward tilts; **units** = "degrees".

2.4.2 Raw SeaStar Data

The following data objects are SDSes belonging to the Vgroup "Raw SeaStar Data". Attributes of the SDSs are shown in **bold**.

sc_id (2-byte integer, array size **Number of Scan Lines** x 2): **long_name** = "Spacecraft ID"; first word includes frame number; second word specifies data mode; see Reference &.

sc_ttag (2-byte integer, array size **Number of Scan Lines** x 4): **long_name** = "Spacecraft time tag"; binary representation of spacecraft time; see Reference &.

sc_soh (byte, array size **Number of Scan Lines** x 775): **long_name** = "Spacecraft state-of-health data"; raw state-of-health telemetry data; see Reference &.

inst_tlm (2-byte integer, array size **Number of Scan Lines** x 44): **long_name** = "SeaWiFS instrument telemetry"; raw instrument and ancillary telemetry data, subcommutated depending on minor frame number and line number within frame; see Reference &.

l1a_data (2-byte integer, array size **Number of Scan Lines** x **Pixels per Scan Line** x 8): **long_name** = "Level-1A data"; **valid_range** = (0,1023); **units** = "radiance counts"; dimensions are scan lines x pixels x bands.

start_syn (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Start-synch pixel"; 8 words with alternating values of 0 and 1023 to indicate the start of the scan line.

stop_syn (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Stop-synch pixel"; 8 words with alternating values of 0 and 1023 to indicate the end of the scan line.

dark_rest (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Dark-restore pixel"; zero-level measurement (in radiance counts) for each band taken from back side of scan.

gain (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Band gain settings"; **valid_range** = (0,3); values are 0 = Earth gain 1, 1 = solar gain 2, 2 = Earth gain, 3 = lunar gain.

tdi (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Band time-delay and integration settings"; **valid_range** = (0,255); specifies detector combination used for each band; see Reference &.

2.4.3 Converted Telemetry

The following data objects are SDSes belonging to the Vgroup "Converted Telemetry". Attributes of the SDSs are shown in **bold**.

inst_ana (4-byte real, array size **Number of Scan Lines** x 40): **long_name** = "Instrument analog telemetry"; 32 instrument analog telemetry data converted to physical units (last 8 word locations are spares); see Table 1.

inst_dis (byte, array size **Number of Scan Lines** x 32): **long_name** = "Instrument discrete telemetry"; 24 instrument discrete telemetry data, unpacked 1 bit per byte (last 8 byte locations are spares); see Table 2.

sc_ana (4-byte real, array size **Number of Scan Lines** x 40): **long_name** = "Spacecraft analog telemetry"; selected spacecraft analog telemetry data converted to physical units; see Table 3.

sc_dis (byte, array size **Number of Scan Lines** x 40): **long_name** = "Spacecraft discrete telemetry"; selected spacecraft discrete telemetry data, unpacked 1 bit per byte; see Table 4.

scan_temp (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Detector temperature counts"; **valid_range** = (0,255); digitized scan temperature for each band.

side (2-byte integer, array size **Number of Scan Lines**): **long_name** = "Mirror side for scan line"; **valid_range** = (0,1).

2.4.4 Navigation

The following data objects are SDSes belonging to the Vgroup "Navigation". Attributes of the SDSs are shown in **bold**. See Reference & for a description of methods used for the operational navigation of SeaWiFS data.

orb_vec (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Orbit position vector at scan line time"; orbit position vector interpolated to the time of the scan line; **valid_range** = (-7200.,7200.); **units** = "kilometers"; used to determine spacecraft position for geolocation.

l_vert (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Local vertical vector in ECEF frame"; local vertical (geodedic) vector at the spacecraft position, in the ECEF frame; **valid_range** = (-1.,1.); used to determine roll and pitch of spacecraft.

sun_ref (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Reference Sun vector in ECEF frame"; unit Sun vector in the Earth-cetered, Earth-fixed (ECEF) frame; **valid_range** = (-1.,1.); used for computing solar zenith and azimuth angles.

att_ang (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Computed yaw, roll, pitch"; **valid_range** = (-180.,180.); relates spacecraft position to orbit reference frame.

sen_mat (4-byte real, array size **Number of Scan Lines** x 3 x 3): **long_name** = "ECEF-to-sensor-frame matrix"; **valid_range** = (-1.,1.); relates sensor scan plane to Earth-fixed reference frame (3x3 matrix, in column-major order).

scan_ell (4-byte real, array size **Number of Scan Lines** x 6): **long_name** = "Scan-track ellipse coefficients"; defines scan-track geometry in sensor frame.

nflag (4-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Navigation flags"; in the 8-integer array, the integers represent, respectively: overall navigation flag; spare; Sun sensor flag; Earth sensor flag; spacecraft attitude uncertainty flag; time code flag; tilt data flag; and spare. All flags may have the value 0 for valid or 1 for invalid. The tilt data flag only may also have the value of 2 to indicate a changing tilt. Note that the overall navigation flag is only to 1 if the attitude uncertainty flag, time code flag or tilt data flag are set to 1.

2.4.5 Sensor Tilt

The following data objects are SDSes belonging to the Vgroup "Sensor Tilt". Attributes of the SDSs are shown in **bold**.

ntilts (4-byte integer): **long_name** = "Number of scene tilt states".

tilt_flags (2-byte integer, array size 20): **long_name** = "Tilt indicators"; **valid_range** = (-1,3); tilt flags corresponding to each tilt state in the scene; possible values are 0 for nadir tilt, 1 for forward tilt, 2 for aft tilt, and 3 to indicate a changing tilt angle; -1 indicates an unknown state; contains **ntilts** valid values.

tilt_ranges (2-byte integer, array size 20 x 2): **long_name** = "Scan-line number ranges of scene tilt states"; first and last scan line numbers (1-relative) corresponding to each tilt state in the scene; contains **ntilts** valid values.

tilt_lats (4-byte real, array size 20 x 2 x 2): **long_name** = "Latitudes of tilt-range scan line end points"; **valid_range** = (-90.,90.); latitudes of the end pixels for the scan lines of **tilt_ranges** (dimensions are **ntilts** x first/last scans x start/end pixels); contains **ntilts** valid values.

tilt_lons (4-byte real, array size 20 x 2 x 2): **long_name** = "Longitudes of tilt-range scan line end points"; **valid_range** = (-180.,180.); longitudes of the end pixels for the scan lines of **tilt_ranges** (dimensions are **ntilts** x first/last scans x start/end pixels); contains **ntilts** valid values.

2.4.6 Calibration

The following data objects are SDSes belonging to the Vgroup "Calibration". Attributes of the SDSs are shown in **bold**. See Reference & for a description of the operational algorithms used for applying the sensor calibration to SeaWiFS Level-1A data. Calibration values are those obtained from the calibration table for the first scan line of this Level-1A product.

entry_year (2-byte integer): **long_name** = "Calibration entry year"; the year (4 digits) that the entry used for this Vgroup's data was made in the sensor calibration table.

entry_day (2-byte integer): **long_name** = "Calibration entry day-of-year"; the day-of-year that the entry used for this Vgroup's data was made in the sensor calibration table.

ref_year (2-byte integer): **long_name** = "Calibration reference year"; 1997; the year of the calibration reference time (time of transfer of the SeaWiFS calibration to orbit).

ref_day (2-byte integer): **long_name** = "Calibration reference day-of-year"; 64; the day of year of the calibration reference time (time of transfer of the SeaWiFS calibration to orbit).

ref_minute (2-byte integer): **long_name** = "Calibration reference minute-of-day"; 720; the minute of day of the calibration reference time (time of transfer of the SeaWiFS calibration to orbit).

mirror (4-byte real, array size 2 x 8): **long_name** = "Mirror-side correction factors"; mirror side-0 and -1 correction factors for calibration of the eight bands (dimensions are sides x bands).

t_const (8-byte real, array size 8): **long_name** = "Time-dependent correction constant terms"; time-dependent correction constant terms for all bands.

t_linear (8-byte real, array size 8): **long_name** = "Time-dependent correction linear coefficients"; time-dependent correction linear coefficients for all bands.

t_quadratic (8-byte real, array size 8): **long_name** = "Time-dependent correction quadratic coefficients"; time-dependent correction quadratic coefficients for all bands.

cal_offs (4-byte real, array size 8): **long_name** = "Calibration system offsets"; calibration system offsets for all bands.

counts (4-byte real, array size 8 x 4 x 5): **long_name** = "Digital counts of calibration knees"; **valid_range** = (0,1023); digital counts (zero-offsets corrected) corresponding to each calibration knee for all gains and bands (dimensions are bands x gains x knees).

rads (4-byte real, array size 8 x 4 x 5): **long_name** = "Radiances of calibration knees"; radiances corresponding to each calibration knee for all gains and bands (dimensions are bands x gains x knees).

2.5 Product Size

The main variables determining the size of Level-1A data products (Table &) is the number of scan lines and the number of pixels per scan line. For full-resolution data (LAC and HRPT), each scan-line of Level-1A data is 1,285 pixels x 8 band values per pixel x 2 bytes per band value = 20,560 bytes. The number of bytes of metadata for each scan line is (by Vgroup): Scan-Line Attributes, 76; Raw SeaStar Data, 955; Converted Telemetry, 410; and Navigation, 140. Therefore, each scan line consists of 20,560 bytes of data and 1,581 bytes of metadata, for a total of 22,141 bytes.

For each Level-1A scene or product, an approximate additional 76,800 bytes (75 KB) of metadata and HDF overhead are required. Assuming an average of 450 scan lines per scenes and 15 full-resolution (LAC) scenes per day, a LAC scene averages (450 x 22,141) + 76,800 = 9.6 MB. This gives a daily volume of 143.5 MB and a (5-year) mission volume of 256 GB.

For GSFC HRPT data, assuming three passes are collected per day with an average of 2,760 scan lines (a total of 23 minutes at 6 scans per second) and the same overhead per file, an HRPT Level-1A file will be (2,760 x 22,141) + 76,800 = 58 MB. This gives a daily volume of 175 MB and a mission volume of 312 GB. Other HRPT station volumes will be similar, except for high-latitude stations which will have larger volumes.

For GAC data, each scan-line of Level-1A data is 248 pixels x 8 bands per pixel x 2 bytes per band = 3,968 bytes. Therefore, each scan line consists of 3,968 bytes of data and 1,581 bytes of metadata, for a total of 5,549 bytes. Assuming 3,600 scan lines per scene (one scene per orbit), a GAC scene averages (3,600 x 5,549) + 76,800 = 19.1 MB. This gives a daily volume (14.5 scenes per day) of 277.3 MB and a mission volume of 494 GB.

Table 1. Converted instrument analog telemetry in **inst_ana**.

Array Indices	Description	Units
1 - 4	Focal plan assembly temperatures	degrees C
5	Telescope motor temperature	degrees C
6 - 7	Tilt base and platform temperatures	degrees C
8	Half angle motor temperature	degress C
9 - 10	Power supply input current (A and B sides)	amps
11 - 12	Analog power voltage (+15V and -15V)	volts
13	5V logical power voltage	volts
14	Power supply temperature	degrees C
15	B1/B2 postamp temperature	degrees C
16	Servo drive temperature	degrees C
17 - 20	Servo power voltage (+30V, +21V, -21V, +5V)	volts
21	Angular momentum compensator speed	rpm
22 - 23	Tilt motor positions (platform and base)	degrees
24	28V heater power	volts
25 - 26	Telescope motor current (A and B sides)	amps
27 - 28	Half angle motor current (A and B sides)	amps

29 - 30	Servo phase error (A and B sides)	millirad
31 - 32	Angular momentum compensator motor current (A and B)	amps
33 - 40	Spares	

Table 2. Converted instrument discrete telemetry in **inst_dis**.

Array index	Description and convention
1	Servo selected (1 = A)
2	Angular momentum compensator on (1 = on)
3	Servo A locked (1 = true)
4	Servo B locked (1 = true)
5	Timing selected (1 = A)
6	Tilt A selected (1 = true)
7	Tilt B selected (1 = true)
8	Tilt telemetry on (1 = on)
9	Stow on (1 = on)
10	Stow aligned (1 = on)
11	Heaters status (1 = enabled)
12	Solar door open (1 = open)
13	Analog power on (1 = on)
14	Tilt platform limit (1 = true)
15	Tilt base limit (1 = true)
16	Tilt nadir aligned (1 = true)
17	Tilt aft aligned (1 = true)
18	Tilt forward aligned (1 = true)
19	Earth mode data on (1 = Earth mode, 0 = solar mode)
20	Half angle mirror side (1 = side 2)
21	Image data sync (1 = true)
22	Angular momentum compensator at speed (1 = true)
23-32	Spares

Table 3. Converted spacecraft analog telemetry in **sc_ana**.

Array Indices	Description	Units
1 - 3	GPS orbit position vector (ECEF frame)	km
4 - 6	GPS orbit velocity vector (ECEF frame)	km/sec
7-9	ACS attitude angles yaw, roll, pitch	degrees
10 - 11	Digital Sun sensor A outputs	n/a
12 - 13	Digital Sun sensor B outputs	n/a
14 - 15	Digital Sun sensor C outputs	n/a
16 - 17	Horizon sensor A angles (phase and chord)	degrees
18 - 19	Horizon sensor B angles (phase and chord)	degrees
20	GPS dilution-of-precision	n/a
21	GPS time-tag fractional second	second
22	Momentum wheel 1 speed	rpm
23	Momentum wheel 1 current	amp
24	Momentum wheel 2 speed	rpm
25	Momentum wheel 2 current	amp
26 - 28	Torquer 1 commanded levels (x, y, z)	amp-m^2
29 - 31	Torquer 1 commanded levels (x, y, z)	amp-m^2
32 - 35	Magnetometer 1 field values (x,y,z,r)	nanotesla
36 - 38	Attitude angle rates (yaw, roll, pitch)	degree/sec
39 - 40	spares	

Table 4. Converted spacecraft discrete telemetry in **sc_dis**.

Array Indices	Description
1 - 3	DSS Sun presence flags (A, B, C)
4 - 6	DSS status (A, B, C)
7 - 8	HS A status
9 - 10	HS B status
11	Number of GPS satellites visible
12	Number of GPS sateliites tracked
13	GPS receiver status
14 - 15	GPS time tag year
16	GPS time tag month
17	GPS time tag day
18 - 20	GPS time tag hour, minute, second
21 - 24	DSS A time tag (milliseconds of week)
25 - 28	DSS B time tag (milliseconds of week)
29 - 32	DSS C time tag (milliseconds of week)
33 - 36	HS A time tag (milliseconds of week)
37 - 40	HS B time tag (milliseconds of week)

3.0 Level-1A Browse Products

3.1 Introduction

A SeaWiFS Level-1A browse product (see Figure &) is generated from a corresponding Level-1A GAC or HRPT product. The main data contents of the product are a subsampled version of the band-8 raw radiance counts image stored as one byte per pixel. Each Level-1A browse product corresponds exactly in geographical coverage (scan-line and pixel extent) to that of its parent Level-1A product and is stored in one physical HDF file.

3.2 Naming Convention

The form of a Level-1A browse file name is Syyyydddhhmmss.L1A_ttt_BRS, where S is for SeaWiFS, yyyydddhhmmss are the concatenated digits for the GMT year, day of the year, hours, minutes, and seconds of the first scan line, and ttt is a three or four character code indicating the data type and (for HRPT data) the receiving station. Examples of file names for each data type are (note that the times in file names of real data from the HRPT stations would, of course, not be the same):

S1996121130809.L1A_GAC_BRS for GAC browse data
S1996121130809.L1A_HNSG_BRS for NASA/GSFC HRPT data
(**Station Name** = "GSFC HRPT, NASA, MD")

3.3 Global Attributes

For global attributes that have constant values specific to this product type, the actual value is given.

3.3.1 Mission and Documentation

Product Name (character): the name of the product file (without path).

Title (character): "SeaWiFS Level-1A Browse Data".

Legend (character): "NASA/GSFC SeaWiFS Level-1A *TTTT* band-8 browse data, day *DDD*, *YYYY*", where *TTTT* is the **Data Type**, and *DDD* and *YYYY* are the day and year portions of the **Start Time**.

Data Center (character): same as for parent product.

Mission (character): "SeaStar SeaWiFS".

Mission Characteristics (character): "Nominal orbit: inclination = 98.2 (Sun-synchronous); node = 12 noon local (descending); eccentricity = <0.002; altitude = 705 km; ground speed = 6.75 km/sec".

Sensor (character): "Sea-viewing Wide Field-of-view Sensor (SeaWiFS)".

Sensor Characteristics (character): "Number of bands = 8; number of active bands = 8; wavelengths per band (nm) = 412, 443, 490, 510, 555, 670, 765, 865; bits per pixel = 10; instantaneous field-of-view = 1.5835 mrad; pixels per scan = 1285; scan rate = 6/sec; sample rate = 7710/sec". Note: Pixels per scan, scan rate, and sample rate are given for the sensor; effective rates for GAC data are lower due to subsampling.

Replacement Flag (character): "ORIGINAL" if this is the first version of this product delivered to the DAAC; otherwise, it is set to the name of the product to be replaced (superseded) by the present product.

Software ID (character): identifies version of the operational software used to create this product.

Processing Time (character): local time of generation of this product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Input Files (character): the name of the Level-1A data file (without path) from which the current product was created. This information is simply stored in the product as part of its processing history.

Processing Control (character): all input and processing control parameters used by the calling program to generate the product. Vertical bars or carriage return characters serve as parameter information delimiters. This information is simply stored in the product as part of its processing history.

Processing Log (character): not used.

3.3.2 Parent Product Information

The following attributes refer to the parent Level-1A data product.

Parent Input Files (character): the name of the Level-0 file (without path) from which the parent product was created.

Station Name (character): same as for parent product.

Station Latitude (4-byte real): same as for parent product.

Station Longitude (4-byte real): same as for parent product.

Data Type (character): same as for parent product.

Parent Pixels per Scan Line (4-byte integer): same as **Pixels per Scan Line** of parent product.

Parent Number of Scan Lines (4-byte integer): same as **Number of Scan Lines** of parent product.

Scene Center Scan Line (4-byte integer): number of the center scan line (1-relative) of the scene, relative to first scan line.

Filled Scan Lines (4-byte integer): not used

FF Missing Frames (4-byte integer): not used

SDPS Missing Frames (4-byte integer): not used

3.3.3 Data Time

The values of the following attributes are identical to those of the parent Level-1A data product.

Start Time (character): start GMT of the first scan line of the scene; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

End Time (character): start GMT of the last scan line of the scene; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Scene Center Time (character): start GMT of the center scan line of the scene; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Node Crossing Time (character): GMT of descending node crossing; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Start Year (2-byte integer): GMT year of first scan line of the scene.

Start Day (2-byte integer): GMT day-of-year of first scan line of the scene.

Start Millisec (4-byte integer): GMT milliseconds-of-day of start of the first scan line of the scene.

End Year (2-byte integer): GMT year of last scan line of the scene.

End Day (2-byte integer): GMT day-of-year of last scan line of the scene.

End Millisec (4-byte integer): GMT milliseconds-of-day of start of the last scan line of the scene.

Start Node (character): "Ascending" or "Descending"; describes node direction at the start of the scene.

End Node (character): "Ascending" or "Descending"; describes node direction at the end of the scene.

Orbit Number (4-byte integer): orbit number of the scene.

NORAD Line 1 (character): not used.

NORAD Line 2 (character): not used

3.3.4 Scene Coordinates

The values of the following attributes are identical to those of the parent Level-1A data product.

Latitude Units (character): "degrees North"; units used for all latitude values in this product.

Longitude Units (character): "degrees East"; units used for all longitude values in this product.

Scene Center Latitude (4-byte real): latitude of the nadir point of the scene's center scan line.

Scene Center Longitude (4-byte real): longitude of the nadir point of the scene's center scan line.

Scene Center Solar Zenith (4-byte real): solar zenith angle of the nadir point of the scene's center scan line.

Northernmost Latitude (4-byte real): northernmost latitude of all scan line end points.

Southernmost Latitude (4-byte real): southernmost latitude of all scan line end points.

Westernmost Longitude (4-byte real): westernmost longitude of all scan line end points.

Easternmost Longitude (4-byte real): easternmost longitude of all scan line end points.

Start Center Latitude (4-byte real): latitude of center pixel for first scan line.

Start Center Longitude (4-byte real): longitude of center pixel for first scan line.

End Center Latitude (4-byte real): latitude of center pixel for last scan line.

End Center Longitude (4-byte real): longitude of center pixel for last scan line.

Orbit Node Longitude (4-byte real): longitude of scene's orbit descending node (longitude at equatorial crossing of day-side node).

3.3.5 Browse Image Information

Parameter (character): "Quasi-true-color composite of level-1A bands 6, 5, and 1".

Units (character): "index into color look-up table".

Start Pixel (4-byte integer): the first pixel of each scan line in the parent product used to create this product; values are 1-relative; normally, 1.

LAC Pixel Start Number (4-byte integer): the LAC pixel number corresponding to the first pixel in scan lines of this product; normally, 147 if **Data Type** = "GAC", else, 1.

Pixel Subsampling Rate (4-byte integer): the pixel subsampling rate (starting with **Start Pixel**) used on parent product to create this product; normally, 2 if **Data Type** = "GAC", else, 8.

LAC Pixel Subsampling (4-byte integer): the subsampling rate for the pixels in this product relative to LAC scan lines; equals **Pixel Subsampling Rate** * the parent's **LAC Pixel Subsampling**.

Pixels per Scan Line (4-byte integer): number of pixels per each scan line in this product; equals the integer portion of ((**Parent Pixels per Scan Line** - **Start Pixel**) / **Pixel Subsampling Rate**) + 1.

Start Scan (4-byte integer): the first scan line in the parent product used to create this product; values are 1-relative; normally, 1.

Scan Subsampling Rate (4-byte integer): the scan-line subsampling rate (starting with **Start Scan**) used on parent product to create this product; normally, 2 if **Data Type** = "GAC", else, 8.

Number of Scan Lines (4-byte integer): number of scan lines in this product; equals the integer portion of ((**Parent Number of Scan Lines** - **Start Scan**) / **Scan Subsampling Rate**) + 1.

Pixel Coordinates (4-byte integer): number of values in **px_ll_first** and **px_ll_last**; normally equals **Pixels per Scan Line**.

Scan Coordinates (4-byte integer): number of values in **sc_ll_first** and **sc_ll_last**; normally equals **Number of Scan Lines**.

Scaling (character): "not applicable".

Scaling Equation (character): "not applicable".

Slope (4-byte real): 1.0 (not used).

Intercept (4-byte real): 0.0 (not used).

3.4 Raster, SDS Arrays, and Vgroups

3.4.1 Image Data and Coordinates

brs_data (byte, array size **Number of Scan Lines** x **Pixels per Scan Line**): raster image array of Level-1A band-8 data; has an associated palette (byte, array size 3 x 256) of red, green, and blue weights for each of 256 (0 to 255, respectively) possible **brs_data** byte values.

px_ll_first (4-byte real, array size **Pixel Coordinates** x 2): **long_name** = "Lat/lon of pixels along first scan line".

px_ll_last (4-byte real, array size **Pixel Coordinates** x 2): **long_name** = "Lat/lon of pixels along last scan line".

sc_ll_first (4-byte real, array size **Scan Coordinates** x 2): **long_name** = "Lat/lon of starts of scan lines".

sc_ll_last (4-byte real, array size **Scan Coordinates** x 2): **long_name** = "Lat/lon of ends of scan lines".

3.4.2 Sensor Tilt

The following data objects are SDSes belonging to the Vgroup "Sensor Tilt". Attributes of the SDSs are shown in **bold**. Note that values relate to the parent Level-1A data product. In particular, scan-line number values of **tilt_ranges** are those of the parent and must be converted to those of the browse product using **Start Scan** and **Scan Subsampling Rate**.

ntilts (4-byte integer): **long_name** = "Number of scene tilt states".

tilt_flags (2-byte integer, array size 20): **long_name** = "Tilt indicators"; **valid_range** = (-1,3); tilt flags corresponding to each tilt state in the scene; possible values are 0 for nadir tilt, 1 for forward tilt, 2 for aft tilt, and 3 to indicate a changing tilt angle; -1 indicates an unknown state; contains **ntilts** valid values.

tilt_ranges (2-byte integer, array size 20 x 2): **long_name** = "Scan-line number ranges of scene tilt states"; first and last scan line numbers (1-relative) corresponding to each tilt state in the scene; contains **ntilts** valid values.

tilt_lats (4-byte real, array size 20 x 2 x 2): **long_name** = "Latitudes of tilt-range scan line end points"; **valid_range** = (-90.,90.); latitudes of the end pixels for the scan lines of **tilt_ranges** (dimensions are **ntilts** x first/last scans x start/end pixels); contains **ntilts** valid values.

tilt_lons (4-byte real, array size 20 x 2 x 2): **long_name** = "Longitudes of tilt-range scan line end points"; **valid_range** = (-180.,180.); longitudes of the end pixels for the scan lines of **tilt_ranges** (dimensions are **ntilts** x first/last scans x start/end pixels); contains **ntilts** valid values.

3.4.3 Navigation

The following data objects are SDSes belonging to the Vgroup "Navigation". Attributes of the SDSs are shown in **bold**. See Reference & for a description of methods used for the operational navigation of SeaWiFS data. The **Number of Scan Lines** dimension corresponds to that of **brs_data**.

orb_vec (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Orbit position vector at scan line time"; orbit position vector interpolated to the time of the scan line; **valid_range** = (-7200.,7200.); **units** = "kilometers"; used to determine spacecraft position for geolocation.

l_vert (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Local vertical vector in ECEF frame"; local vertical (geodedic) vector at the spacecraft position, in the ECEF frame; **valid_range** = (-1.,1.); used to determine roll and pitch of spacecraft.

sun_ref (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Reference Sun vector in ECEF frame"; unit Sun vector in the Earth-cetered, Earth-fixed (ECEF) frame; **valid_range** = (-1.,1.); used for computing solar zenith and azimuth angles.

att_ang (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Computed yaw, roll, pitch"; **valid_range** = (-180.,180.); relates spacecraft position to orbit reference frame.

sen_mat (4-byte real, array size **Number of Scan Lines** x 3 x 3): **long_name** = "ECEF-to-sensor-frame matrix"; **valid_range** = (-1.,1.); relates sensor scan plane to Earth-fixed reference frame (3x3 matrix, in column-major order).

scan_ell (4-byte real, array size **Number of Scan Lines** x 6): **long_name** = "Scan-track ellipse coefficients"; defines scan-track geometry in sensor frame.

nflag (4-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Navigation flags"; in the 8-integer array, the integers represent, respectively: overall navigation flag; spare; Sun sensor flag; Earth sensor flag; spacecraft attitude uncertainty flag; time code flag; tilt data flag; and spare. All flags may have the value 0 for valid or 1 for invalid. The tilt data flag only may also have the value of 2 to indicate a changing tilt. Note that the overall navigation flag is only to 1 if the attitude uncertainty flag, time code flag or tilt data flag are set to 1.

3.5 Product Size

The main variables determining the size of Level-1A browse products (Table &) are the pixel and scan subsampling rates and the number of scan lines in the parent product. For HRPT data, assuming subsampling rates of 8, the **brs_data** array will be (1285 x scan lines)/(8x8), or about 20 bytes per scan line. Using the average number of scan lines and HRPT passes used for the Level-1A data volume calculations, and assuming about 25 KB of metadata and HDF overhead per file, the average file sizes and the daily and mission volumes for the HRPT browse products are, respectively:

GSFC	0.077 MB	0.23 MB	0.41 GB
Stennis	0.095 MB	0.19 MB	0.34 GB
Honolulu	0.064 MB	0.13 MB	0.23 GB
San Diego	0.069 MB	0.14 MB	0.25 GB
Anchorage	0.059 MB	0.41 Mb	0.74 GB

for an average of 0.07 MB per file and daily and mission totals of 1.1 MB and 2.0 GB.

For GAC data, assuming subsampling rates of 2 and 3,600 scan lines in the parent file, the **brs_data** array will be (248x3600) / (2x2) = 218.0 KB. With about 15 KB of metadata and HDF overhead, a Level-1A GAC browse product averages about 0.23 MB, for a daily volume (14.5 scenes per day) of 3.3 MB and a mission volume of 5.9 GB. The combined Level-1A GAC and HRPT browse volumes then will be 4.4 MB per day and 7.9 GB for the mission.

4.0 Level-2 GAC Data Product

4.1 Introduction

A SeaWiFS Level-2 GAC product (see Figure &) is generated from a corresponding Level-1A GAC product. The main data contents of the product are the geophysical values for each pixel, derived from the Level-1A raw radiance counts by applying the sensor calibration, atmospheric corrections, and bio-optical algorithms. Each Level-2 GAC product corresponds exactly in geographical coverage (scan-line and pixel extent) to that of its parent Level-1A product and is stored in one physical HDF file.

4.2 Naming Convention

The form of a Level-2 GAC file name is Syyyydddhhmmss.L2_GAC, where S is for SeaWiFS, and yyyydddhhmmss are the concatenated digits for the GMT year, day of the year, hours, minutes, and seconds of the first scan line. An example of a Level-2 GAC file name is:

S1996121130809.L2_GAC

4.3 Global Attributes

For global attributes that have constant values specific to this product type, the actual value is given.

4.3.1 Mission and Documentation

Product Name (character): the name of the product file (without path).

Title (character): "SeaWiFS Level-2 Data".

Data Center (character): "NASA/GSFC SeaWiFS Data Processing Center".

Station Name (character): "Wallops Flight Facility".

Station Latitude (4-byte real): 37.9272.

Station Longitude (4-byte real): -75.4753.

Mission (character): "SeaStar SeaWiFS".

Mission Characteristics (character): "Nominal orbit: inclination = 98.2 (Sun-synchronous); node = 12 noon local (descending); eccentricity = <0.002; altitude = 705 km; ground speed = 6.75 km/sec".

Sensor (character): "Sea-viewing Wide Field-of-view Sensor (SeaWiFS)".

Sensor Name (character): "SeaWiFS".

Sensor Characteristics (character): "Number of bands = 8; number of active bands = 8; wavelengths per band (nm) = 412, 443, 490, 510, 555, 670, 765, 865; bits per pixel = 10; instantaneous field-of-view = 1.5835 mrad; pixels per scan = 1285; scan rate = 6/sec; sample rate = 7710/sec". Note: Pixels per scan, scan rate, and sample rate are given for the sensor; effective rates for GAC data are lower due to subsampling.

Data Type (character): "GAC".

Replacement Flag (character): "ORIGINAL" if this is the first version of this product delivered to the DAAC; otherwise, it is set to the name of the product to be replaced (superseded) by the present product.

Software Name (character): "MSl12"; name of the software used to create this product.

Software Version (character): version of the software used to create this product.

Processing Time (character): local time of generation of this product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Processing Control (character): path and name of the file containing the control parameters. This information is simply stored in the product as part of its processing history.

Input Parameters (character): all input and processing control parameters used by the calling program to generate the product. Vertical bars or carriage return characters serve as parameter information delimiters. This information is simply stored in the product as part of its processing history.

Input Files (character): the names of the Level-1A GAC file (without path; always listed first) from which the current product was created and of the ancillary (environmental) data files (without paths, each separated by one comma) used in the processing. This information is simply stored in the product as part of its processing history.

4.3.2 Data Time

Start Time (character): start GMT of the first scan line of the scene; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

End Time (character): start GMT of the last scan line of the scene; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Scene Center Time (character): start GMT of the center scan line of the scene; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Node Crossing Time (character): GMT of descending node crossing; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Start Year (2-byte integer): GMT year of first scan line of the scene.

Start Day (2-byte integer): GMT day-of-year of first scan line of the scene.

Start Millisec (4-byte integer): GMT milliseconds-of-day of start of the first scan line of the scene.

End Year (2-byte integer): GMT year of last scan line of the scene.

End Day (2-byte integer): GMT day-of-year of last scan line of the scene.

End Millisec (4-byte integer): GMT milliseconds-of-day of start of the last scan line of the scene.

Start Node (character): "Ascending" or "Descending"; describes node direction at the start of the scene.

End Node (character): "Ascending" or "Descending"; describes node direction at the end of the scene.

Orbit Number (4-byte integer): orbit number of the scene.

4.3.3 Data Quality

Pixels per Scan Line (4-byte integer): 248.

Number of Scan Lines (4-byte integer): number of scan lines in the scene.

Number of Bands (4-byte integer): 8; number of SeaWiFS channels/wavelengths.

LAC Pixel Start Number (4-byte integer): 147; the LAC pixel number corresponding to the first pixel in scan lines of this product.

LAC Pixel Subsampling (4-byte integer): 4; the subsampling rate for the pixels in this product relative to LAC scan lines.

Scene Center Scan Line (4-byte integer): number of the center scan line (1-relative) of the scene, relative to first scan line.

Number of Scan Control Points (4-byte integer): number of rows in the **latitude** and **longitude** control point arrays.

Number of Pixel Control Points (4-byte integer): number of columns in the **latitude** and **longitude** control point arrays.

Mask Names (character): list of algorithm names (each separated by one comma, from the values of the attributes **f01_name** to **f24_name** of the **l2_flags** SDS in the Geophysical Data Vgroup) for the flag bits that were used as masks when generating this product.

Flag Percentages (4-byte real, array size 32): percentages of pixels in the scene for which a bit in **l2_flags** is set; each of the 32 values corresponds to one of the 32 bits (from lowest to highest) in **l2_flags**.

4.3.4 Scene Coordinates

Latitude Units (character): "degrees North"; units used for all latitude values in this product.

Longitude Units (character): "degrees East"; units used for all longitude values in this product.

Scene Center Latitude (4-byte real): latitude of the nadir point of the scene's center scan line.

Scene Center Longitude (4-byte real): longitude of the nadir point of the scene's center scan line.

Scene Center Solar Zenith (4-byte real): solar zenith angle of the nadir point of the scene's center scan line.

Upper Left Latitude (4-byte real): latitude of the upper left scene corner.

Upper Left Longitude (4-byte real): longitude of the upper left scene corner.

Upper Right Latitude (4-byte real): latitude of the upper right scene corner.

Upper Right Longitude (4-byte real): longitude of the upper right scene corner.

Lower Left Latitude (4-byte real): latitude of the lower left scene corner.

Lower Left Longitude (4-byte real): longitude of the lower left scene corner.

Lower Right Latitude (4-byte real): latitude of the lower right scene corner.

Lower Right Longitude (4-byte real): longitude of the lower right scene corner.

Northernmost Latitude (4-byte real): northernmost latitude of all scan line end points.

Southernmost Latitude (4-byte real): southernmost latitude of all scan line end points.

Westernmost Longitude (4-byte real): westernmost longitude of all scan line end points.

Easternmost Longitude (4-byte real): easternmost longitude of all scan line end points.

Start Center Latitude (4-byte real): latitude of center pixel for first scan line.

Start Center Longitude (4-byte real): longitude of center pixel for first scan line.

End Center Latitude (4-byte real): latitude of center pixel for last scan line.

End Center Longitude (4-byte real): longitude of center pixel for last scan line.

Orbit Node Longitude (4-byte real): longitude of scene's orbit descending node (longitude at equatorial crossing of day-side node).

4.4 Vgroups

Of the following six Vgroups, three (Scan-Line Attributes, Geophysical Data, and Navigation) contain data that are functions of scan lines. That is, each data object within these Vgroups have data for each scan line and is therefore dimensioned by the value of the global attribute, **Number of Scan Lines**. Thus, to get all the data corresponding to a specific scan line, n, the n^{th} values of all data objects in these four Vgroups would need to be read.

4.4.1 Scan-Line Attributes

The following data objects are SDSes belonging to the Vgroup "Scan-Line Attributes". Attributes of the SDSs are shown in **bold**.

year (4-byte integer, array size **Number of Scan Lines**): **long_name** = "Scan year"; **valid_range** = (1996, 2038); **units** = "years".

day (4-byte integer, array size **Number of Scan Lines**): **long_name** = "Scan day of year; **valid_range** = (1,366); **units** = "days".

msec (4-byte integer, array size **Number of Scan Lines**): **long_name** = "Scan-line time, milliseconds of day"; **valid_range** = (0,86399999), **units** = "milliseconds".

slat (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan start-pixel latitude"; **valid_range** = (-90.,90.); **units** = "degrees".

slon (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan start-pixel longitude"; **valid_range** = (-180.,180.); **units** = "degrees".

clat (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan center-pixel latitude"; **valid_range** = (-90.,90.); **units** = "degrees".

clon (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan center-pixel longitude"; **valid_range** = (-180.,180.); **units** = "degrees".

elat (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan end-pixel latitude"; **valid_range** = (-90.,90.); **units** = "degrees".

elon (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan end-pixel longitude"; **valid_range** = (-180.,180.); **units** = "degrees".

csol_z (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan center-pixel solar zenith angle"; **valid_range** = (0.,180.); **units** = "degrees".

4.4.2 Geophysical Data

The following data objects are SDSes belonging to the Vgroup "Geophysical Data". Attributes of the SDSs are shown in **bold**. The parameters are stored as two-byte integers, which are scaled according to the attributes **slope** and i**ntercept** attached to each SDS. The scalings, range and units are summarized in Table 6.

nLw_412 (2-byte integer, array size **Number of Scan Lines** x **Pixels per Scan Line**): **long_name** = "Normalized water-leaving radiance at 412 nm"; **slope** = 0.001; **intercept** = 0.0; **units** = "mW cm^-2 um^-1 sr^-1"; **slope** and **intercept** must be used to convert the integer values of **nLw_412** into real-valued, geophysical units: **nLw_412*****slope** + **intercept** (see Table 6); if not calculable, this field is set to zero.

nLw_443 (2-byte integer, array size **Number of Scan Lines** x **Pixels per Scan Line**): **long_name** = "Normalized water-leaving radiance at 443 nm"; **slope** = 0.001; **intercept** = 0.0; **units** = "mW cm^-2 um^-1 sr^-1"; **slope** and **intercept** must be used to convert the integer values of **nLw_443** into real-valued, geophysical units: **nLw_443*****slope** + **intercept** (see Table 6); if not calculable, this field is set to zero.

nLw_490 (2-byte integer, array size **Number of Scan Lines** x **Pixels per Scan Line**): **long_name** = "Normalized water-leaving radiance at 490 nm"; **slope** = 0.001; **intercept** = 0.0; **units** = "mW cm^-2 um^-1 sr^-1"; **slope** and **intercept** must be used to convert the integer values of **nLw_490** into real-valued, geophysical units: **nLw_490*****slope** + **intercept** (see Table 6); if not calculable, this field is set to zero.

nLw_510 (2-byte integer, array size **Number of Scan Lines** x **Pixels per Scan Line**): **long_name** = "Normalized water-leaving radiance at 510 nm"; **slope** = 0.001; **intercept** = 0.0; **units** = "mW cm^-2 um^-1 sr^-1"; **slope** and **intercept** must be used to convert the integer values of **nLw_510** into real-valued, geophysical units: **nLw_510*****slope** + **intercept** (see Table 6); if not calculable, this field is set to zero.

nLw_555 (2-byte integer, array size **Number of Scan Lines** x **Pixels per Scan Line**): **long_name** = "Normalized water-leaving radiance at 555 nm"; **slope** = 0.001; **intercept** = 0.0; **units** = "mW cm^-2 um^-1 sr^-1"; **slope** and **intercept** must be used to convert the integer values of **nLw_555** into real-valued, geophysical units: **nLw_555*****slope** + **intercept** (see Table 6); if not calculable, this field is set to zero.

nLw_670 (2-byte integer, array size **Number of Scan Lines** x **Pixels per Scan Line**): **long_name** = "Normalized water-leaving radiance at 670 nm"; **slope** = 0.0001; **intercept** = 0.0; **units** = "mW cm^-2 um^-1 sr^-1"; **slope** and **intercept** must be used to convert the integer values of **nLw_670** into real-valued, geophysical units: **nLw_670*****slope** + **intercept** (see Table 6); if not calculable, this field is set to zero.

chlor_a (2-byte integer, array size **Number of Scan Lines** x **Pixels per Scan Line**): **long_name** = "Chlorophyll Concentration, OC4 Algorithm"; **slope** = 0.001; **intercept** = 32.0; **units** = "mg m^-3"; **slope** and **intercept** must be used to convert the integer values of **chlor_a** into real-valued, geophysical units: **chlor_a*****slope** + **intercept** (see Table 6); if not calculable, this field is set to zero.

K_490 (2-byte integer, array size **Number of Scan Lines** x **Pixels per Scan Line**): **long_name** = "Diffuse attenuation coefficient at 490 nm"; **slope** = 0.0002; **intercept** = 0.0; **units** = "m^-1"; **slope** and **intercept** must be used to convert the integer values of **K_490** into real-valued, geophysical units: **K_490*****slope** + **intercept** (see Table 6); if not calculable, this field is set to zero.

eps_78 (byte, array size **Number of Scan Lines** x **Pixels per Scan Line**): **long_name** = "Epsilon of aerosol correction at 765 and 865 nm"; **slope** = 0.01; **intercept** = 0.0; **units** = "dimensionless"; **slope** and **intercept** must be used to convert the byte values of **eps_78** into real-valued, geophysical units: **eps_78*****slope** + **intercept** (see Table 6); if not calculable, this field is set to zero.

tau_865 (2-byte integer, array size **Number of Scan Lines** x **Pixels per Scan Line**): **long_name** = "Aerosol optical thickness at 865 nm"; **slope** = 0.0001; **intercept** = 0.0; **units** = "dimensionless"; **slope** and **intercept** must be used to convert the byte values of **tau_865** into real-valued, geophysical units: **tau_865*****slope** + **intercept** (see Table 6); if not calculable, this field is set to zero.

angstrom_510 (2-byte integer, array size **Number of Scan Lines** x **Pixels per Scan Line**): **long_name** = "Angstrom coefficient, 510 to 865 nm"; **slope** = 0.0002; **intercept** = 0.0; **units** = "dimensionless"; **slope** and **intercept** must be used to convert the byte values of **angstrom_510** into real-valued, geophysical units: **angstrom_510*****slope** + **intercept** (see Table 6); if not calculable, this field is set to zero.

l2_flags (4-byte integer, array size **Number of Scan Lines** x **Pixels per Scan Line**): **long_name** = "Level-2 Processing Flags"; 32 bits in two bytes used as indicators of certain conditions (see Table 5). The following attributes provide the names of the algorithms (also listed in Table 5) used in determining the setting of the corresponding bits in **l2_flags** (the least significant bit being the first bit): **f01_name** = "ATMFAIL"; **f02_name** = "LAND"; **f03_name** = "BADANC"; **f04_name** = "HIGLINT"; **f05_name** = "HILT"; **f06_name** = "HISATZEN"; **f07_name** = "COASTZ"; **f08_name** = "NEGLW"; **f09_name** = "STRAYLIGHT"; **f10_name** = "CLDICE"; **f11_name** = "COCCOLITH"; **f12_name** = "TURBIDW"; **f13_name** = "HISOLZEN"; **f14_name** = "HITAU"; **f15_name** = "LOWLW"; **f16_name** = "CHLFAIL"; **f17_name** = "NAVWARN"; **f18_name** = "ABSAER"; **f19_name** = "TRICHO"; **f20_name** = "MAXAERITER"; **f21_name** = "MODGLINT"; **f22_name** = "CHLWARN"; **f23_name** = "ATMWARN"; **f24_name** = "DARKPIXEL"; **f25_name** through **f32_name** = "SPARE". The algorithms associated with these names, and the use of the corresponding bits as masks or as flags, are described in Reference & and, for "STRAYLIGHT", Reference &.

Table 5. Conditions indicated for the pixel associated with the setting of individual bits in l**2_flags**. These correspond to the algorithm names given by the attributes of **l2_flags**.

Bit Set = 1	**Condition Indicated**	**Algorithm Name**
1	atmospheric correction failure from invalid inputs	ATMFAIL
2	land	LAND
3	missing ancillary data	BADANC
4	severe Sun glint	HIGLINT
5	total radiance above knee in any band	HILT
6	satellite zenith angle above limit	HISATZEN
7	shallow water	COASTZ
8	negative water-leaving radiance in any band	NEGLW
9	stray light contamination	STRAYLIGHT
10	clouds and/or ice	CLDICE
11	coccolithophore	COCCOLITH
12	turbid, case-2 water	TURBIDW
13	solar zenith angle above limit	HISOLZEN
14	high aerosol concentration	HITAU
15	low water-leaving radiacne at 555 nm	LOWLW
16	chlorophyll not calculable	CHLFAIL
17	questionable navigation (e.g, tilt change)	NAVWARN
18	absorbing aerosol index above threshold	ABSAER
19	trichodesmium	TRICHO
20	maximum iterations of NIR algorithm	MAXAERITER
21	moderate Sun glint	MODGLINT
22	chlorophyll out of range	CHLWARN
23	epsilon out of range	ATMWARN
24	dark pixel (Lt - Lt < 0) for any band	DARKPIXEL
25 - 32	spare flags	SPARE

Table 6. Summary of Level-2 geophysical parameter scalings.

Parameter	Storage (bytes)	Slope	Intercept	Approximate Range	Units
nLw_412	2	0.001	0.0	0 - 32	mw cm^{-2} um^{-1} sr^{-1}
nLw_443	2	0.001	0.0	0 - 32	mw cm^{-2} um^{-1} sr^{-1}
nLw_490	2	0.001	0.0	0 - 32	mw cm^{-2} um^{-1} sr^{-1}
nLw_510	2	0.001	0.0	0 - 32	mw cm^{-2} um^{-1} sr^{-1}
nLw_555	2	0.001	0.0	0 - 32	mw cm^{-2} um^{-1} sr^{-1}
nLw_670	2	0.0001	0.0	0 - 3.2	mw cm^{-2} um^{-1} sr^{-1}
chlor_a	2	0.001	32.0	0 - 64	mg m^{-3}
K_490	2	0.0002	0.0	0 - 6.4	m^{-1}
tau_865	2	0.0001	0.0	0 - 3.2	none
angstrom_510	2	0.0002	0.0	-6.4 - 6.4	none
eps_78	1	0.01	0.0	0 - 2.5	none

4.4.3 Navigation

The following data objects are SDSes belonging to the Vgroup "Navigation". Attributes of the SDSs are shown in **bold**. See Reference & for a description of methods used for the operational navigation of SeaWiFS data. Note that the control point arrays **latitude** and **longitude** are intended to be used for display only; the most accurate geolocation will be obtained using **orb_vec**, **sen_mat**, and **scan_ell** with the SeaWiFS Project software.

orb_vec (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Orbit position vector at scan line time"; orbit position vector interpolated to the time of the scan line; **valid_range** = (-7200.,7200.); **units** = "kilometers"; used to determine spacecraft position for geolocation.

sun_ref (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Reference Sun vector in ECEF frame"; unit Sun vector in the Earth-cetered, Earth-fixed (ECEF) frame; **valid_range** = (-1.,1.); used for computing solar zenith and azimuth angles.

att_ang (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Computed yaw, roll, pitch"; **valid_range** = (-180.,180.); relates spacecraft position to orbit reference frame.

sen_mat (4-byte real, array size **Number of Scan Lines** x 3 x 3): **long_name** = "ECEF-to-sensor-frame matrix"; **valid_range** = (-1.,1.); relates sensor scan plane to Earth-fixed reference frame (3x3 matrix, in column-major order).

scan_ell (4-byte real, array size **Number of Scan Lines** x 6): **long_name** = "Scan-track ellipse coefficients"; defines scan-track geometry in sensor frame.

nflag (4-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Navigation flags"; in the 8-integer array, the integers represent, respectively: overall navigation flag; spare; Sun sensor flag; Earth sensor flag; spacecraft attitude uncertainty flag; time code flag; tilt data flag; and spare. All flags may have the value 0 for valid or 1 for invalid. The tilt data flag only may also have the value of 2 to indicate a changing tilt. Note that the overall navigation flag is only to 1 if the attitude uncertainty flag, time code flag or tilt data flag are set to 1.

cntl_pt_cols (4-byte integer, array size **Number of Pixel Control Points**): **long_name** = "Pixel control points"; **units** = "none"; array of pixel indices corresponding to **latitude** and **longitude** SDSs.

cntl_pt_rows (4-byte integer, array size **Number of Scan Control Points**): **long_name** = "Scan control points"; **units** = "none"; array of scan line indices corresponding to **latitude** and **longitude** SDSs.

longitude (4-byte real, array size **Number of Scan Control Points** x **Number of Pixel Control Points**): **long_name** = "Longitudes at control points";**units** = "degrees"; **valid_range** = "-180., 180."; **units** = "degrees"; longitudes of pixels indicated by **cntl_pt_cols** and **cntl_pt_rows**.

latitude (4-byte real, array size **Number of Scan Control Points** x **Number of Pixel Control Points**): **long_name** = "Latitudes at control points";**units** = "degrees"; **valid_range** = "-90., 90."; **units** = "degrees"; latitudes of pixels indicated by **cntl_pt_cols** and **cntl_pt_rows**.

tilt (4-byte real, array size **Number of Scan Lines**): **long_name** = "Tilt angle for scan line"; **valid_range** = (-20.1,20.1); **units** = "degrees"; positive values indicate aft tilts and negative values indicate forward tilts.

4.4.4 Sensor Tilt

The following data objects are SDSes belonging to the Vgroup "Sensor Tilt". Attributes of the SDSs are shown in **bold**.

ntilts (4-byte integer): **long_name** = "Number of scene tilt states".

tilt_flags (2-byte integer, array size 20): **long_name** = "Tilt indicators"; **valid_range** = (-1,3); tilt flags corresponding to each tilt state in the scene; possible values are 0 for nadir tilt, 1 for forward tilt, 2 for aft tilt, and 3 to indicate a changing tilt angle; -1 indicates an unknown state; contains **ntilts** valid values.

tilt_ranges (2-byte integer, array size 20 x 2): **long_name** = "Scan-line number ranges of scene tilt states"; first and last scan line numbers (1-relative) corresponding to each tilt state in the scene; contains **ntilts** valid values.

4.4.5 Sensor Band Parameters

The following data objects are SDSes belonging to the Vgroup "Sensor Band Parameters". Attributes of the SDSs are shown in **bold**. These parameters are used in the Level 2 processing.

wavelength (4-byte integer, array size **Number of Bands**); **long_name** = "Wavelengths"; **units** = "nm"; band center wavelength for each SeaWiFS band.

vcal_gain (4-byte real, array size **Number of Bands**); **long_name** = "Vicarious Calibration Gain"; **units** = "dimensionless"; vicarious calibration gain for each SeaWiFS band.

vcal_offset (4-byte real, array size **Number of Bands**); **long_name** = "Vicarious Calibration Offset"; **units** = "mW cm^-2 um^-1 sr^-1"; vicarious calibration offset for each SeaWiFS band.

F0 (4-byte real, array size **Number of Bands**); **long_name** = "Mean Solar Flux"; **units** = "mW cm^-2 um^-1 sr^-1"; mean solar flux for each SeaWiFS band.

k_oz (4-byte real, array size **Number of Bands**); **long_name** = "Ozone Absorption Coefficient"; **units** = "cm^-1"; ozone absorption coefficient for each SeaWiFS band.

Tau_r (4-byte real, array size **Number of Bands**); **long_name** = "Rayleigh Optical Thickness"; **units** = "dimensionless"; Rayleigh optical thickness for each SeaWiFS band.

4.4.6 Calibration

The following data objects are SDSes belonging to the Vgroup "Calibration". Attributes of the SDSs are shown in **bold**. See Reference & for a description of the operational algorithms used for applying the sensor calibration to SeaWiFS Level-1A data. Calibration values are those obtained from the calibration table for the first scan line of this Level-1A product.

entry_year (2-byte integer): **long_name** = "Calibration entry year"; the year (4 digits) that the entry used for this Vgroup's data was made in the sensor calibration table.

entry_day (2-byte integer): **long_name** = "Calibration entry day-of-year"; the day-of-year that the entry used for this Vgroup's data was made in the sensor calibration table.

ref_year (2-byte integer): **long_name** = "Calibration reference year"; 1997; the year of the calibration reference time (time of transfer of the SeaWiFS calibration to orbit).

ref_day (2-byte integer): **long_name** = "Calibration reference day-of-year"; 64; the day of year of the calibration reference time (time of transfer of the SeaWiFS calibration to orbit).

ref_minute (2-byte integer): **long_name** = "Calibration reference minute-of-day"; 720; the minute of day of the calibration reference time (time of transfer of the SeaWiFS calibration to orbit).

mirror (4-byte real, array size 2 x 8): **long_name** = "Mirror-side correction factors"; mirror side-0 and -1 correction factors for calibration of the eight bands (dimensions are sides x bands).

t_const (8-byte real, array size 8): **long_name** = "Time-dependent correction constant terms"; time-dependent correction constant terms for all bands.

t_linear (8-byte real, array size 8): **long_name** = "Time-dependent correction linear coefficients"; time-dependent correction linear coefficients for all bands.

t_quadratic (8-byte real, array size 8): **long_name** = "Time-dependent correction quadratic coefficients"; time-dependent correction quadratic coefficients for all bands.

cal_offs (4-byte real, array size 8): **long_name** = "Calibration system offsets"; calibration system offsets for all bands.

counts (4-byte real, array size 8 x 4 x 5): **long_name** = "Digital counts of calibration knees"; **valid_range** = (0,1023); digital counts (zero-offsets corrected) corresponding to each calibration knee for all gains and bands (dimensions are bands x gains x knees).

rads (4-byte real, array size 8 x 4 x 5): **long_name** = "Radiances of calibration knees"; radiances corresponding to each calibration knee for all gains and bands (dimensions are bands x gains x knees).

4.6 Product Size

Each Level-2 pixel consists of 10 two-byte geophysical values, 1 one-byte value, and a four-byte **l2_flags** field, or a total of 25 bytes per pixel. Therefore, each scan-line is 248 pixels x 25 bytes per pixel = 6,200 bytes. The number of bytes of metadata for each scan line is (by Vgroup): Scan-Line Attributes, 44; and Navigation, 384. Therefore, each scan line consists of 6,200 bytes of data and 428 bytes of metadata, for a total of 6,628 bytes.

The main variable in determining the size of Level-2 GAC data products (Table &) is the number of scan lines in the scene. Assuming 3,600 scan lines per scene (one scene per orbit), and 75 KB of additional metadata and HDF overhead, a Level-2 GAC product averages (3,600 x 6,628) + 75 KB = 22.8 MB. This gives a daily volume (14.5 scenes per day) of 331 MB and a mission volume of 590 GB.

5.0 Level-2 Browse Product

5.1 Introduction

A SeaWiFS Level-2 browse product (see Figure &) is generated from a corresponding Level-2 GAC product. The main data contents of the product are a subsampled version of the chlorophyll *a* image stored as one byte per pixel. Each Level-2 browse product corresponds exactly in geographical coverage (scan-line and pixel extent) to that of its parent Level-2 product and is stored in one physical HDF file.

5.2 Naming Convention

The form of a Level-2 browse file name is Syyyydddhhmmss.L2_BRS, where S is for SeaWiFS, and yyyydddhhmmss are the concatenated digits for the GMT year, day of the year, hours, minutes, and seconds of the first scan line. An example of a Level-2 browse file name is:

S1996121130809.L2_BRS

5.3 Global Attributes

For global attributes that have constant values specific to this product type, the actual value is given.

5.3.1 Mission and Documentation

Product Name (character): the name of the product file (without path).

Title (character): "SeaWiFS Level-2 Browse Data".

Legend (character): "NASA/GSFC SeaWiFS Level-2 GAC chlorophyll a browse data, day *DDD*, *YYYY*", where *DDD* and *YYYY* are the day and year portions of the **Start Time**.

Data Center (character): "NASA/GSFC SeaWiFS Data Processing Center".

Mission (character): "SeaStar SeaWiFS".

Mission Characteristics (character): "Nominal orbit: inclination = 98.2 (Sun-synchronous); node = 12 noon local (descending); eccentricity = <0.002; altitude = 705 km; ground speed = 6.75 km/sec".

Sensor (character): "Sea-viewing Wide Field-of-view Sensor (SeaWiFS)".

Sensor Name (character): "SeaWiFS".

Sensor Characteristics (character): "Number of bands = 8; number of active bands = 8; wavelengths per band (nm) = 412, 443, 490, 510, 555, 670, 765, 865; bits per pixel = 10; instantaneous field-of-view = 1.5835 mrad; pixels per scan = 1285; scan rate = 6/sec; sample rate = 7710/sec". Note: Pixels per scan, scan rate, and sample rate are given for the sensor; effective rates for GAC data are lower due to subsampling.

Replacement Flag (character): "ORIGINAL" if this is the first version of this product delivered to the DAAC; otherwise, it is set to the name of the product to be replaced (superseded) by the present product.

Software Name (character): "l2brsgen"; name of the software used to create this product.

Software Version (character): version of the software used to create this product.

Processing Time (character): local time of generation of this product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Input Files (character): the name of the Level-2 GAC file (without path) from which the current product was created. This information is simply stored in the product as part of its processing history.

Processing Control (character): path and name of the file containing the control parameters. This information is simply stored in the product as part of its processing history.

5.3.2 Parent Product Information

The following attributes refer to the parent Level-2 GAC product.

Parent Input Files (character): the names of the Level-1A GAC file (without path) from which the parent product was created and of the ancillary (environmental) data files (without paths, each separated by one comma) used in the processing.

Station Name (character): "Wallops Flight Facility".

Station Latitude (4-byte real): 37.9272.

Station Longitude (4-byte real): -75.4753.

Data Type (character): "GAC".

Parent Pixels per Scan Line (4-byte integer): 248.

Parent Number of Scan Lines (4-byte integer): number of scan lines in the scene.

Scene Center Scan Line (4-byte integer): number of the center scan line (1-relative) of the scene, relative to first scan line.

Flag Percentages (4-byte real, array size 32): percentages of pixels in the scene for which a bit in **l2_flags** is set; values corresponds to one of the 32 bits (from lowest to highest) in **l2_flags**.

5.3.3 Data Time

The values of the following attributes are identical to those of the parent Level-2 GAC product.

Start Time (character): start GMT of the first scan line of the scene; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

End Time (character): start GMT of the last scan line of the scene; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Scene Center Time (character): start GMT of the center scan line of the scene; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Node Crossing Time (character): GMT of descending node crossing; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Start Year (2-byte integer): GMT year of first scan line of the scene.

Start Day (2-byte integer): GMT day-of-year of first scan line of the scene.

Start Millisec (4-byte integer): GMT milliseconds-of-day of start of the first scan line of the scene.

End Year (2-byte integer): GMT year of last scan line of the scene.

End Day (2-byte integer): GMT day-of-year of last scan line of the scene.

End Millisec (4-byte integer): GMT milliseconds-of-day of start of the last scan line of the scene.

Start Node (character): "Ascending" or "Descending"; describes node direction at the start of the scene.

End Node (character): "Ascending" or "Descending"; describes node direction at the end of the scene.

Orbit Number (4-byte integer): orbit number of the scene.

5.3.4 Scene Coordinates

The values of the following attributes are identical to those of the parent Level-2 GAC product.

Latitude Units (character): "degrees North"; units used for all latitude values in this product.

Longitude Units (character): "degrees East"; units used for all longitude values in this product.

Scene Center Latitude (4-byte real): latitude of the nadir point of the scene’s center scan line.

Scene Center Longitude (4-byte real): longitude of the nadir point of the scene's center scan line.

Scene Center Solar Zenith (4-byte real): solar zenith angle of the nadir point of the scene's center scan line.

Upper Left Latitude (4-byte real): latitude of the upper left scene corner.

Upper Left Longitude (4-byte real): longitude of the upper left scene corner.

Upper Right Latitude (4-byte real): latitude of the upper right scene corner.

Upper Right Longitude (4-byte real): longitude of the upper right scene corner.

Lower Left Latitude (4-byte real): latitude of the lower left scene corner.

Lower Left Longitude (4-byte real): longitude of the lower left scene corner.

Lower Right Latitude (4-byte real): latitude of the lower right scene corner.

Lower Right Longitude (4-byte real): longitude of the lower right scene corner.

Northernmost Latitude (4-byte real): northernmost latitude of all scan line end points.

Southernmost Latitude (4-byte real): southernmost latitude of all scan line end points.

Westernmost Longitude (4-byte real): westernmost longitude of all scan line end points.

Easternmost Longitude (4-byte real): easternmost longitude of all scan line end points.

Start Center Latitude (4-byte real): latitude of center pixel for first scan line.

Start Center Longitude (4-byte real): longitude of center pixel for first scan line.

End Center Latitude (4-byte real): latitude of center pixel for last scan line.

End Center Longitude (4-byte real): longitude of center pixel for last scan line.

Orbit Node Longitude (4-byte real): longitude of scene's orbit descending node (longitude at equatorial crossing of day-side node).

5.3.5 Browse Image Information

Parameter (character): "Chlorophyll a concentration".

Units (character): "mg m^-3".

Start Pixel (4-byte integer): the first pixel of each scan line in the parent product used to create this product; values are 1-relative; normally, 1.

LAC Pixel Start Number (4-byte integer): normally, 147; the LAC pixel number corresponding to the first pixel in scan lines of this product.

Pixel Subsampling Rate (4-byte integer): the pixel subsampling rate (starting with **Start Pixel**) used on parent product to create this product; normally, 2.

LAC Pixel Subsampling (4-byte integer): the subsampling rate for the pixels in this product relative to LAC scan lines; equals **Pixel Subsampling Rate** * the parent's **LAC Pixel Subsampling**; normally, 8.

Pixels per Scan Line (4-byte integer): number of pixels per each scan line in this product; equals the integer portion of ((**Parent Pixels per Scan Line** - **Start Pixel**) / **Pixel Subsampling Rate**) + 1.

Start Scan (4-byte integer): the first scan line in the parent product used to create this product; values are 1-relative; normally, 1.

Scan Subsampling Rate (4-byte integer): the scan-line subsampling rate (starting with **Start Scan**) used on parent product to create this product; normally, 2.

Number of Scan Lines (4-byte integer): number of scan lines in this product; equals the integer portion of ((**Parent Number of Scan Lines** - **Start Scan**) / **Scan Subsampling Rate**) + 1.

Pixel Coordinates (4-byte integer): number of values in **px_ll_first** and **px_ll_last**; normally equals **Pixels per Scan Line**.

Scan Coordinates (4-byte integer): number of values in **sc_ll_first** and **sc_ll_last**; normally equals **Number of Scan Lines**.

Scaling (character): "logarithmic".

Scaling Equation (character): "Base**((Slope*brs_data) + Intercept) = chlorophyll a".

Base (4-byte real): 10.0; used to convert the byte values (0-250) of **brs_data** into mg m^{-3} of chlorophyll *a*: **Base****((**Slope*****brs_data**) + **Intercept**) = chlorophyll *a*.

Slope (4-byte real): 0.015; used to convert the byte values (0-250) of **brs_data** into mg m^{-3} of chlorophyll *a*: **Base****((**Slope*****brs_data**) + **Intercept**) = chlorophyll *a*.

Intercept (4-byte real): -2.0; used to convert the byte values (0-250) of **brs_data** into mg m^{-3} of chlorophyll *a*: **Base****((**Slope*****brs_data**) + **Intercept**) = chlorophyll *a*.

5.4 Raster, SDS Arrays, and Vgroups

5.4.1 Image Data and Coordinates

brs_data (byte, array size **Number of Scan Lines** x **Pixels per Scan Line**): raster image array of chlorophyll *a* data; may be converted into real values using **Base**, **Slope**, and **Intercept**; has an associated palette (byte, array size 3 x 256) of red, green, and blue weights for each of 256 (0 to 255, respectively) possible **brs_data** byte values. Byte values 251 to 255 in the raster image are reserved to indicate certain conditions (in the order of highest to lowest priority): 255 for pixels in scan lines for which, in the parent Level-2 product, **s_flags** (Vgroup "Scan-Line Attributes") indicates any missing bands or **nflag** (Vgroup "Navigation") indicates invalid navigation, 253 for pixels whose associated **l2_flags** in the parent Level-2 product have the land flag (bit 2) set, 254 for those with the **l2_flags** cloud and ice flag (bit 10) set, 252 for those with the **l2_flags** glint flag (bit 4) set, and 251 if any other **l2_flags** bits used as masks are set.

px_ll_first (4-byte real, array size **Pixel Coordinates** x 2): **long_name** = "Lat/lon of pixels along first scan line".

px_ll_last (4-byte real, array size **Pixel Coordinates** x 2): **long_name** = "Lat/lon of pixels along last scan line".

sc_ll_first (4-byte real, array size **Scan Coordinates** x 2): **long_name** = "Lat/lon of starts of scan lines".

sc_ll_last (4-byte real, array size **Scan Coordinates** x 2): **long_name** = "Lat/lon of ends of scan lines".

5.4.2 Sensor Tilt

The following data objects are SDSes belonging to the Vgroup "Sensor Tilt". Attributes of the SDSs are shown in **bold**. Note that values relate to the parent Level-2 GAC data product. In particular, scan-line number values of **tilt_ranges** are those of the parent and must be converted to those of the browse product using **Start Scan** and **Scan Subsampling Rate**.

ntilts (4-byte integer): **long_name** = "Number of scene tilt states".

tilt_flags (2-byte integer, array size 20): **long_name** = "Tilt indicators"; **valid_range** = (-1,3); tilt flags corresponding to each tilt state in the scene; possible values are 0 for nadir tilt, 1 for forward tilt, 2 for aft tilt, and 3 to indicate a changing tilt angle; -1 indicates an unknown state; contains **ntilts** valid values.

tilt_ranges (2-byte integer, array size 20 x 2): **long_name** = "Scan-line number ranges of scene tilt states"; first and last scan line numbers (1-relative) corresponding to each tilt state in the scene; contains **ntilts** valid values.

5.4.3 Navigation

The following data objects are SDSes belonging to the Vgroup "Navigation". Attributes of the SDSs are shown in **bold**. See Reference & for a description of methods used for the operational navigation of SeaWiFS data. The **Number of Scan Lines** dimension corresponds to that of **brs_data**.

orb_vec (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Orbit position vector at scan line time"; orbit position vector interpolated to the time of the scan line; **valid_range** = (-7200.,7200.); **units** = "kilometers"; used to determine spacecraft position for geolocation.

sun_ref (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Reference Sun vector in ECEF frame"; unit Sun vector in the Earth-cetered, Earth-fixed (ECEF) frame; **valid_range** = (-1.,1.); used for computing solar zenith and azimuth angles.

att_ang (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Computed yaw, roll, pitch"; **valid_range** = (-180.,180.); relates spacecraft position to orbit reference frame.

sen_mat (4-byte real, array size **Number of Scan Lines** x 3 x 3): **long_name** = "ECEF-to-sensor-frame matrix"; **valid_range** = (-1.,1.); relates sensor scan plane to Earth-fixed reference frame (3x3 matrix, in column-major order).

scan_ell (4-byte real, array size **Number of Scan Lines** x 6): **long_name** = "Scan-track ellipse coefficients"; defines scan-track geometry in sensor frame.

nflag (4-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Navigation flags"; in the 8-integer array, the integers represent, respectively: overall navigation flag; spare; Sun sensor flag; Earth sensor flag; spacecraft attitude uncertainty flag; time code flag; tilt data flag; and spare. All flags may have the value 0 for valid or 1 for invalid. The tilt data flag only may also have the value of 2 to indicate a changing tilt. Note that the overall navigation flag is only to 1 if the attitude uncertainty flag, time code flag or tilt data flag are set to 1.

5.5 Product Size

The main variables determining the size of Level-2 browse products (Table &) are the pixel and scan subsampling rates and the number of scan lines in the parent product. Assuming subsampling rates of 2 and 3,600 scan lines in the parent file, the **brs_data** array will be (248x3600) / (2x2) = 218 KB. With about 15 KB of metadata and HDF overhead, a Level-2 browse product averages about 0.23 MB, for a daily volume (14.5 scenes per day) of 3.3 MB and a mission volume of 5.9 GB.

6.0 Level-3 Binned Data Products

6.1 Introduction

Each SeaWiFS Level-3 binned data product consists of the accumulated data for all Level-2 GAC products corresponding to a period of one day, 8 days, a calendar month, or a calendar year. The data are stored in a representation of a global, equal-area grid whose grid cells, or "bins," are approximately 81 km^2. See Reference & for a discussion of the theoretical basis of the binning algorithm, a summary of the algorithm, and the specification of the geographical and temporal specifications of the scheme. See Reference & for the definition of a day with respect to SeaWiFS data selected for daily binning--a "data day."

Whether or not a pixel from a parent Level-2 product is excluded from binning during the space binning step is determined by the existence of any of the following conditions:

1. A bit in the parent Level-2 product's **l2_flags** corresponding to the pixel is set (equals 1) and the algorithm name for that bit has been specified to be used for exclusion by an input parameter to the space binner.

2. The pixel's scan line is within a **tilt_ranges** range in the parent Level-2 product for which the corresponding **tilt_flags** is 3 (changing tilt angle) or -1 (unknown state).

Note that for condition 2, the entire scan line of that pixel will be excluded. The time binning step is used to combine scene bin products, generated by the space binner, into daily products. Time binning is used in turn to combine day bin products into 8-day and monthly products and monthly bin products into yearly products.

Each Level-3 binned data product will be stored in multiple HDF files. Each multi-file product includes a main file containing all product-level metadata and data for each bin that are common to all the binned geophysical parameters. In addition, each product includes 12 subordinate files (class = **DataSubordinate**), each of which contains data of one binned geophysical parameter for all bins. Subordinate files must be read in conjunction with the associated main file.

Note that the first 512 bytes (block) of each subordinate file contain an ASCII string equal to the global attribute **Product Name**. This physical block is not an HDF data object and the main file contains the pointers to skip this block when accessing the logical objects. Although not part of the specifications, the existence of this block is noted here since it can be useful to identify a subordinate file should its name be changed inadvertently.

6.2 Naming Convention

For a Level-3 binned data product, the form of the name of the main file is Syyyydddyyyyddd.L3b_ttt, where S is for SeaWiFS, and yyyydddyyyyddd are the concatenated digits for the GMT year and day of the year of the start and end days of the binning period, and ttt is a code for the binning period length. Binning period codes are DAY, 8D, MO, and YR. For daily products, only the year and day of the data are used; i.e., yyyyddd. Subordinate files have an extension xff appended to the name,

where ff is a file number ranging from 00 to 11. Note that the "day of the year" for these products represents the dataday (see Reference &, Appendix &) which may overlap calendar days to a small extent.

An example of a daily product's name is:

S1996121.L3b_DAY
S1996121.L3b_DAY.x00
S1996121.L3b_DAY.x01
S1996121.L3b_DAY.x02
S1996121.L3b_DAY.x03
S1996121.L3b_DAY.x04
S1996121.L3b_DAY.x05
S1996121.L3b_DAY.x06
S1996121.L3b_DAY.x07
S1996121.L3b_DAY.x08
S1996121.L3b_DAY.x09
S1996121.L3b_DAY.x10
S1996121.L3b_DAY.x11

Examples of product names for other binning periods are:

8-day: S19960171996024.L3b_8D
S19960171996024.L3b_8D.x00
" "
S19960171996024.L3b_8D.x11

month: S19960321996060.L3b_MO
S19960321996060.L3b_MO.x00
" "
S19960321996060.L3b_MO.x11

year: S19960011996366.L3b_YR
S19960011996366.L3b_YR.x00
" "
S19960011996366.L3b_YR.x11

Note that 8-day binning periods are continuous, starting from the first day of each calendar year.

Although it is not necessary to know the contents of the subordinate files in order to use them (HDF software will automatically access them as needed when using the main file), the files numbered 00 to 11 contain the _sum and _sum_sq fields (see below) of the following geophysical parameters, respectively: nLw_412, nLw_443, nLw_490, nLw_510, nLw_555, nLw_670, angstrom_510, chlor_a, K_490, chlor_a_K_490, eps_78, and tau_865.

6.3 Global Attributes

For global attributes that have constant values specific to this product type, the actual value is given.

6.3.1 Mission and Documentation

Product Name (character): the name of the product main file (without path).

Title (character): "SeaWiFS Level-3 Binned Data".

Data Center (character): "NASA/GSFC SeaWiFS Data Processing Center".

Station Name (character): "Wallops Flight Facility".

Station Latitude (4-byte real): 37.9272.

Station Longitude (4-byte real): -75.4753.

Mission (character): "SeaStar SeaWiFS".

Mission Characteristics (character): "Nominal orbit: inclination = 98.2 (Sun-synchronous); node = 12 noon local (descending); eccentricity = <0.002; altitude = 705 km; ground speed = 6.75 km/sec".

Sensor (character): "Sea-viewing Wide Field-of-view Sensor (SeaWiFS)".

Sensor Name (character): "SeaWiFS"

Sensor Characteristics (character): "Number of bands = 8; number of active bands = 8; wavelengths per band (nm) = 412, 443, 490, 510, 555, 670, 765, 865; bits per pixel = 10; instantaneous field-of-view = 1.5835 mrad; pixels per scan = 1285; scan rate = 6/sec; sample rate = 7710/sec". Note: Pixels per scan, scan rate, and sample rate are given for the sensor; effective rates for GAC data are lower due to subsampling.

Product Type (character): "day", "8-day", "month", or "year".

Replacement Flag (character): "ORIGINAL" if this is the first version of this product delivered to the DAAC; otherwise, it is set to the name of the product to be replaced (superseded) by the present product.

Processing Time (character): local time of generation of this product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Software Name (character): "BIN"; name of the software used to create this product.

Software Version (character): version of the software used to create this product.

Processing Control (character): path and name of the file containing the control parameters. This information is simply stored in the product as part of its processing history.

Input Parameters (character): all input and processing control parameters used by the calling program to generate the product. Vertical bars or carriage return characters serve as parameter

information delimiters. This information is simply stored in the product as part of its processing history.

Input Files (character): the names of the Level-3 (scene or time-binned data) products (main file names without paths, each separated by one comma) from which the current product was created. This information is simply stored in the product as part of its processing history.

L2 Flag Names (character): list of algorithm names (each separated by one comma) for the flag bits; same names and order as the values of the attributes **f01_name** to **f32_name** of the **l2_flags** SDS in parent Level-2 products.

6.3.2 Data Time

Period Start Year (2-byte integer): year of start of binning period (cf. **Start Year**); used for interpreting **time_rec** of Vdata **BinList** when **Product Type** = "8-day", "month", or "year".

Period Start Day (2-byte integer): GMT day-of-year of start of binning period (cf. **Start Day**); used for interpreting **time_rec** of Vdata **BinList** when **Product Type** = "8-day", "month", or "year".

Period End Year (2-byte integer): year of end of binning period (cf. **End Year**); used for interpreting **time_rec** of Vdata **BinList** when **Product Type** = "8-day", "month", or "year".

Period End Day (2-byte integer): GMT day-of-year of end of binning period (cf. **End Day**); used for interpreting **time_rec** of Vdata **BinList** when **Product Type** = "8-day", "month", or "year".

Start Time (character): start GMT of earliest input product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

End Time (character): end GMT of latest input product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Start Year (2-byte integer): GMT year of data start for earliest input product.

Start Day (2-byte integer): GMT day-of-year of data start for earliest input product.

Start Millisec (4-byte integer): GMT milliseconds-of-day of data start for earliest input product.

End Year (2-byte integer): GMT year of data end for latest input product.

End Day (2-byte integer): GMT day-of-year of data end for latest input product.

End Millisec (4-byte integer): GMT milliseconds-of-day of data end for latest input product.

Orbit (4-byte integer): number of the orbit crossing 180^{o} longitude closest to equator at the start of the binning period.

Start Orbit (4-byte integer): number of the first orbit that may contribute data to this product; used for interpreting **time_rec** of Vdata **BinList** when **Product Type** = "day". This is the first orbit

considered for binning into this product and had at least part of its data collected within the binning period. **Start Orbit** must be =<**Orbit** and will normally be =**Orbit** minus 1 or 2.

End Orbit (4-byte integer): number of the last orbit that may contribute data to this product. This is the last orbit considered for binning into this product and had at least part of its data collected within the binning period. **Last Orbit** will be greater (normally, by 1 or 2) than or equal to the orbit that crosses 180^{o} longitude closest to equator at the end of the binning period.

6.3.3 Data Description

Latitude Units (character): "degrees North"; units used for all latitude values in this product.

Longitude Units (character): "degrees East"; units used for all longitude values in this product.

Northernmost Latitude (4-byte real): center latitude of northernmost data-containing bin.

Southernmost Latitude (4-byte real): center latitude of southernmost data-containing bin.

Westernmost Longitude (4-byte real): center longitude of westernmost data-containing bin.

Easternmost Longitude (4-byte real): center longitude of easternmost data-containing bin.

Data Bins (4-byte integer): number of bins stored in this product; i.e., the number of bins containing data; ranges from 1 to a maximum of 5,940,422.

Percent Data Bins (4-byte real): percent of bins in the grid that contain data; equals **Data Bins** * 100 / 5940422.

Units (character): concatenated strings giving units for each geophysical parameter Vdata in this product; "nLw_412:mW cm^-2 um^-1 sr^-1, nLw_443:mW cm^-2 um^-1 sr^-1, nLw_490:mW cm^-2 um^-1 sr^-1, nLw_510:mW cm^-2 um^-1 sr^-1, nLw_555:mW cm^-2 um^-1 sr^-1, nLw_670:mW cm^-2 um^-1 sr^-1, angstrom_510:dimensionless, chlor_a:mg m^-3, K_490:m^-1, chlor_a_K_490:mg m^-3 / m^-1, eps_78:dimensionless,tau_865:dimensionless".

6.4 Level-3 Binned Data Vgroup in Main File

The Level-3 binned data product Vdatas listed in each subsection below belong to the Vgroup **Level-3 Binned Data** which is of class **PlanetaryGrid**. For SeaWiFS Level-3 binned data products, this Vgroup is spread over multiple HDF files: a main file and 12 subordinate files (Figure &). The main file contains the global attributes described above as well as the Vdatas described in this subsection.

6.4.1 Vdata SEAGrid of Class Geometry

This Vdata contains information needed for description of the geographic binning scheme to HDF access software (see Refence &) and may not be useful to most users.

Vdata **SEAGrid** of class **Geometry** contains one record of the following fields.

registration (4-byte integer): 5; location of characteristic point within bin.

straddle (4-byte integer): 0 (no); does a latitudinal band straddle the equator?

bins (4-byte integer): 4,320; number of equatorial bins.

radius (8-byte real): 6,378.137; Earth's radius in kilometers.

max_north (8-byte real): 90.0; northernmost latitude in grid.

max_south (8-byte real): -90.0; southernmost latitude in grid.

seam_lon (8-byte real): -180.0; longitude of westernmost edge of grid.

6.4.2 Vdata BinIndex of Class Index

Vdata **BinIndex** of class **Index** contains one record of the following fields for each of the 2,160 latitudinal bin rows in the geographic binning scheme. This Vdata contains information needed for description of the geographic binning scheme to HDF access software (see Refence &) and may not be useful to most users.

row_num (4-byte integer): index of row (0 to 2,159) corresponding to each **BinIndex** record.

vsize (8-byte real): north-south extent (degrees latitude) of bins for each row; 0.0833333 (1/12 of a degree) for all rows.

hsize (8-byte real): east-west extent (degrees longitude) of bins for each row; ranges from 0.0833333 for the two equatorial rows to 120.0 for the two polar rows.

start_num (4-byte integer): bin number of first bin in the grid for each row (cf. **begin**); always the same set of values for the set of rows: 1 for row 0, 4 for row 1,..., 5940420 for row 2159 (see Reference &).

begin (4-byte integer): bin number of first data-containing bin for each row (cf. **start_num**).

extent (4-byte integer): number of bins actually stored (i.e., containing data) for each row.

max (4-byte integer): the maximum number of bins in the grid for each row; ranges from 3 for the two polar rows to 4,320 for the two equatorial rows.

6.4.3 Vdata BinList of Class DataMain

Vdata **BinList** of class **DataMain** contains one record of the following fields for each bin in which at least one pixel was binned. Records for bins in which no pixels were binned (**nsamps** = 0) are excluded from the product.

bin_num (4-byte integer): the index number of the bin represented by this record and corresponding records in each of the Vdatas of class **DataSubordinate**; ranges from 1 to maximum of 5,940,422.

nobs (2-byte integer): number of observations (pixels) binned in this bin.

nscenes (2-byte integer): number of scenes contributing data (at least one pixel) to this bin.

time_rec (2-byte integer): the bit sequence represents the time distribution of the data binned in this bin, the least significant bit being the earliest. When **Product Type** = "day", bits correspond to the relative sequence of orbits binned for that data day; each bit represents one orbit starting with the first bit representing **Start Orbit**; the 16^{th} bit represents the 16^{th} and greater orbits binned for that data day. When **Product Type** = "8-day", "month", or "year", the bits represent consecutive time in the binning period (as defined by the global attributes **Period Start Year**, **Period Start Day**, **Period End Year**, and **Period End Day**); for 8-day products, each bit represents one day; for monthly products, each bit represents two days; for yearly products, each bit represents one calendar month. A bit is set (equals 1) only if data for the orbit or time corresponding to that bit were binned in this bin.

weights (4-byte real): sum of the weights of the equivalent bins of the input products (see Reference &).

sel_cat (byte): selection category representing the selection criteria used for binning (not currently used).

flags_set (2-byte integer): 16 bits in two bytes corresponding to those of the parent Level-2 products' **l2_flags**; a bit is set (=1) if any pixel in that bin had the corresponding bit set in the **l2_flags** value.

6.5 Level-3 Binned Data Vgroup in Subordinate Files

The Level-3 binned product Vdatas listed below belong to the Vgroup **Level-3 Binned Data** which is of class **PlanetaryGrid**. For SeaWiFS Level-3 binned data products, this Vgroup is spread over multiple HDF files: a main file and 12 subordinate files (Figure &). Each subordinate file consists of one Vdata of class **DataSubordinate** and each Vdata is named for the geophysical quantity being binned as follows:

nLw_412: normalized water-leaving radiance (mW cm^{-2} um^{-1} sr^{-1}) at 412 nm.

nLw_443: normalized water-leaving radiance (mW cm^{-2} um^{-1} sr^{-1}) at 443 nm.

nLw_490: normalized water-leaving radiance (mW cm^{-2} um^{-1} sr^{-1}) at 490 nm.

nLw_510: normalized water-leaving radiance (mW cm^{-2} um^{-1} sr^{-1}) at 510 nm.

nLw_555: normalized water-leaving radiance (mW cm^{-2} um^{-1} sr^{-1}) at 555 nm.

nLw_670: aerosol radiance (mW cm^{-2} um^{-1} sr^{-1}) at 670 nm.

angstrom_510: angstrom coefficient, 510 to 865 nm.

chlor_a: chlorophyll *a* concentration (mg m^{-3}).

K_490: diffuse attenuation coefficient (m^{-1}) at 490 nm.

chlor_a_K_490: integral chlorophyll (mg m^{-2}), calculated using the Level-2 values chlorophyll *a* divided by K(490).

eps_78: epsilon of aerosol correction at 765 and 865 nm.

tau_865: aerosol optical thickness at 865 nm.

For each file containing a Vdata of the class **DataSubordinate**, the name of the main file (same as content of the global attribute **Product Name**) is written in ASCII starting with the first byte of the file, byte 0. The data records of these Vdatas start at byte 512 in each file. Each Vdata contains two fields, the names of which are made up of the name of the Vdata itself concatenated with **_sum** and **_sum_sq**, as, for example, **nLw_412_sum** and **nLw_412_sum_sq**:

_sum (4-byte real): sum of binned pixel values for corresponding geophysical parameter.

_sum_sq (4-byte real): sum of squares of binned pixel values for corresponding geophysical parameter.

6.6 Product Size

The main variable in determining the size of Level-3 binned data products is the number of bins contained therein (global attribute **Data Bins**). Each bin requires 17 bytes in a main file and 8 bytes in each subordinate files.

For daily binned data products, the number of data bins is reduced from the maximum due to land, clouds, coverage limitations and flagged data. The daily number of bins averages about 0.53×10^6. With about 500 KB of metadata and overhead, a main file requires (0.53×10^6 x 17) + 500 KB = 9.5 MB. The subordinate files will be 0.53×10^6 x 8 = 4 MB each, having almost no overhead associated with them. With one daily binned data product per day, the daily volume is 9.5 + (12 x 4) = 57.5 MB and the mission volume is 102.5 GB.

For longer-term binned data products, satellite coverage will be essentially complete and few if any bin areas will have completely cloudy data, so that the number of data bins will be reduced only by the factor of 0.67 to account for land areas. The number of data-containing bins will therefore be about $0.67 \times 5.94 \times 10^6 = 3.98 \times 10^6$. With about 100 KB of metadata and overhead, a main file requires (3.98×10^6 x 17) + 100 KB = 64.62 MB. The subordinate files will be 3.98×10^6 x 8 = 30.37 MB each, having almost no overhead associated with them, for a total product size of 64.62 + (12 x 30.37) = 429.1 MB.

The average number of longer-term products generated each day will be 0.125 for 8-day products, 0.033 for month-long products, and 0.003 for yearly products, for a total of about 0.16 products per day. This will produce a daily volume of 0.16 x 429.1 = 68.7 MB and a mission volume of 122 GB.

7.0 Level-3 Standard Mapped Image Products

7.1 Introduction

The Level-3 standard mapped image (SMI) products are image representations of binned data products. The data object, **l3m-data**, in each SMI product represents an image of the parameter specified by the global attribute **Parameter**. This object is a byte-valued, two-dimensional array of an Equidistant Cylindrical projection of the globe. The byte values are scaled real values and may be converted to geophysical values using the global attributes **Scaling**, **Scaling Equation**, **Base**, **Slope**, and **Intercept** (see Table &).

Five SMI products are generated from each binned data product, one for each of the following geophysical parameters: chlorophyll *a* concentration, angstrom coefficient 510 to 865 nm, normalized water-leaving radiance at 555 nm, aerosol optical thickness at 865 nm, and diffuse attenuation coefficient at 490 nm. Thus, each SMI product represents data binned over the period covered by the parent product. The mean is used in each case to obtain the values for the SMI grid points from the binned data products. Each SMI product contains one image of a geophysical parameter and is stored in one physical HDF file.

7.2 Naming Convention

The root file names of SMI products correspond to those of their parent binned data products, indicating the binning periods as part of the names. The file name extensions are of the form L3m_ttt_pppp, where ttt represents the binning period length and pppp is a code for the geophysical parameter of the product. From each binned data product, five SMI products are generated with the following parameter codes: CHLO for chlor_a, A510 for angstrom_510, L555 for nLw_555, T865 for tau_865, and K490 for K_490.

For the sample binned data product names given in the previous section, the following SMI products would be generated:

day: S1996121.L3m_DAY_CHLO
S1996121.L3m_DAY_A510
S1996121.L3m_DAY_L555
S1996121.L3m_DAY_T865
S1996121.L3m_DAY_K490

8-day: S19960171996024.L3m_8D_CHLO
S19960171996024.L3m_8D_A510
S19960171996024.L3m_8D_L555
S19960171996024.L3m_8D_T865
S19960171996024.L3m_8D_K490

month: S19960321996060.L3m_MO_CHLO
S19960321996060.L3m_MO_A510
S19960321996060.L3m_MO_L555

S19960321996060.L3m_MO_T865
S19960321996060.L3m_MO_K490

year: S19960011996366.L3m_YR_CHLO
S19960011996366.L3m_YR_A510
S19960011996366.L3m_YR_L555
S19960011996366.L3m_YR_T865
S19960011996366.L3m_YR_K490

7.3 Global Attributes

For global attributes that have constant values specific to this product type, the actual value is given.

7.3.1 Mission and Documentation

Product Name (character): the name of the product file (without path).

Title (character): "SeaWiFS Level-3 Standard Mapped Image".

Data Center (character): "NASA/GSFC SeaWiFS Data Processing Center".

Station Name (character): "Wallops Flight Facility".

Station Latitude (4-byte real): 37.9272.

Station Longitude (4-byte real): -75.4753.

Mission (character): "SeaStar SeaWiFS".

Mission Characteristics (character): "Nominal orbit: inclination = 98.2 (Sun-synchronous); node = 12 noon local (descending); eccentricity = <0.002; altitude = 705 km; ground speed = 6.75 km/sec".

Sensor (character): "Sea-viewing Wide Field-of-view Sensor (SeaWiFS)".

Sensor Name (character): "SeaWiFS".

Sensor Characteristics (character): "Number of bands = 8; number of active bands = 8; wavelengths per band (nm) = 412, 443, 490, 510, 555, 670, 765, 865; bits per pixel = 10; instantaneous field-of-view = 1.5835 mrad; pixels per scan = 1285; scan rate = 6/sec; sample rate = 7710/sec". Note: Pixels per scan, scan rate, and sample rate are given for the sensor; effective rates for GAC data are lower due to subsampling.

Product Type (character): "day", "8-day", "month", or "year".

Replacement Flag (character): "ORIGINAL" if this is the first version of this product delivered to the DAAC; otherwise, it is set to the name of the product to be replaced (superseded) by the present product.

Software Name (character): "smigen"; name of the software used to create this product.

Software Version (character): version of the software used to create this product.

Processing Time (character): local time of generation of this product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Processing Control (character): path and name of the file containing the control parameters. This information is simply stored in the product as part of its processing history.

Input Parameters (character): all input and processing control parameters used by the calling program to generate the product. Vertical bars or carriage return characters serve as parameter information delimiters. This information is simply stored in the product as part of its processing history.

Input Files (character): the name of the Level-3 binned data product (main file name without path) from which the current product was created. This information is simply stored in the product as part of its processing history.

L2 Flag Names (character): same as for parent Level-3 binned product.

7.3.2 Data Time

Period Start Year (2-byte integer): year of start of binning period (cf. **Start Year**) of the parent product.

Period Start Day (2-byte integer): GMT day-of-year of start of binning period (cf. **Start Day**) of the parent product.

Period End Year (2-byte integer): year of end of binning period (cf. **End Year**) of the parent product.

Period End Day (2-byte integer): GMT day-of-year of end of binning period (cf. **End Day**) of the parent product.

Start Time (character): data start GMT as read from the parent product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

End Time (character): data end GMT as read from parent product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Start Year (2-byte integer): GMT year of data start as read from parent product.

Start Day (2-byte integer): GMT day-of-year of data start as read from parent product.

Start Millisec (4-byte integer): GMT milliseconds-of-day of data start as read from parent product.

End Year (2-byte integer): GMT year of data end as read from parent product.

End Day (2-byte integer): GMT day-of-year of data end as read from parent product.

End Millisec (4-byte integer): GMT milliseconds-of-day of data end as read from parent product.

Orbit (4-byte integer): number of the orbit crossing 180^{o} longitude closest to equator at the start, as read from parent product.

Start Orbit (4-byte integer): number of the first orbit that may have contributed data, as read from parent product.

End Orbit (4-byte integer): number of the last orbit that may have contributed data, as read from parent product.

7.3.3 Scene Coordinates

Map Projection (character): "Equidistant Cylindrical".

Latitude Units (character): "degrees North"; units used for all latitude values in this product.

Longitude Units (character): "degrees East"; units used for all longitude values in this product.

Northernmost Latitude (4-byte real): 90.0.

Southernmost Latitude (4-byte real): -90.0.

Westernmost Longitude (4-byte real): -180.0.

Easternmost Longitude (4-byte real): 180.0.

Latitude Step (4-byte real): 0.087890624; latitudinal distance between lines.

Longitude Step (4-byte real): 0.087890624; longitudinal distance between columns.

SW Point Latitude (4-byte real): -89.956054688; latitude of data point for southwesternmost grid cell to indicate location of data center within each grid cell; equals **Southernmost Latitude** + (**Latitude Step**/2.0).

SW Point Longitude (4-byte real): -179.956054688; longitude of data point for southwesternmost grid cell to indicate location of data center within each grid cell; equals **Westernmost Longitude** + (**Longitude Step**/2.0).

7.3.4 Data Description

Data Bins (4-byte integer): number of bins containing data in the parent product; ranges from 1 to a maximum of 5,940,422.

Number of Lines (4-byte integer): 2,048; number of points in the vertical (longitudinal) direction.

Number of Columns (4-byte integer): 4,096; number of points in the horizontal (latitudinal) direction.

Parameter (character): one of "Chlorophyll a concentration", "Angstrom coefficient, 510 to 865 nm", "Normalized water-leaving radiance at 555 nm", "Aerosol optical thickness at 865 nm", or "Diffuse attenuation coefficient at 490 nm".

Measure (character): "Mean".

Units (character): "mg m^-3", blank, "mW cm^-2 um^-1 sr^-1", blank, or "m^-1", corresponding, respectively, to the **Parameter** value.

Scaling (character): "logarithmic" or "linear"; see Table 7.

Scaling Equation (character): "Base**((Slope*l3m_data) + Intercept) = Parameter value", if **Scaling** = "logarithmic"; else, "(Slope*l3m_data) + Intercept = Parameter value"; see Table &.

Base (4-byte real): 10.0, if **Scaling** = "logarithmic"; else, **Base** is not included as a global attribute; used to convert the byte values (0-255) of **l3m_data** into geophysical parameters by **Base****((**Slope*****l3m_data**) + **Intercept**); see Table 7.

Slope (4-byte real): used to convert the byte values (0-255) of **l3m_data** into geophysical values by **Base****((**Slope*****l3m_data**) + **Intercept**), if **Scaling** = "logarithmic", or (**Slope*****l3m_data**) + **Intercept**, if **Scaling** = "linear"; see Table 7.

Intercept (4-byte real): used to convert the byte values (0-255) of **l3m_data** into geophysical values by **Base****((**Slope*****l3m_data**) + **Intercept**), if **Scaling** = "logarithmic", or (**Slope*****l3m_data**) + **Intercept**, if **Scaling** = "linear"; see Table 7.

Data Minimum (4-byte real): minimum value of the input data used to generate **l3m_data**.

Data Maximum (4-byte real): maximum value of the input data used to generate **l3m_data**.

7.4 SDS and Palette Arrays

l3m_data (byte, array size **Number of Lines** x **Number of Columns**): array of chlorophyll *a* data; may be converted into real values using **Base**, **Slope**, and **Intercept**; see Table 7. A **l3m_data** value of 255 is reserved to indicate "no data"; i.e., a bin for this geographic location does not exist in the parent Level-3 binned product.

palette (byte, array size 3 x 256): red, green, and blue weights for each of 256 (0 to 255, respectively) possible **l3m_data** byte values.

Table 7. Summary of Level-3 standard mapped parameter scalings.

Parameter	Type	Slope	Intercept	Approximate Range	Units
chlor_a	log_{10}	0.015	-2.0	0 - 64	mg m^{-3}
angstrom_510	linear	0.02	-0.5	-0.5 - 4.6	none
nLw_555	linear	0.02	0	0 - 5.1	"mW cm^{-2} um^{-1} sr^{-1}"
tau_865	linear	0.005	0	0 - 1.27	none
K_490	log_{10}	0.011	-2.0	0 - 6.4	m^{-1}

7.5 Product Size

SMI products are of almost constant size (Table &) since their main data object, the SDS **l3m_data**, is a constant 8 MB, a file being approximately 8.07 MB. With an average of 1.16 binned data products per day, 5 x 1.16 = 5.8 SMI products are produced. For SMI products therefore, the daily volume is 46.8 MB and the mission volume is 83.4 GB.

8.0 Level-3 Browse Products

8.1 Introduction

A SeaWiFS Level-3 browse product (see Figure &) is generated from a corresponding chlorophyll *a* SMI product. The main data contents of the product are a subsampled version of the SMI image array, **l3m_data**, stored as one byte per pixel. Each Level-3 browse product is stored in one physical HDF file.

8.2 Naming Convention

The root file name of a Level-3 browse product corresponds to that of its parent SMI product, indicating the binning period as part of the name. The file name extension is of the form L3_BRS_ttt, where ttt represents the binning period length.

For the sample SMI product names given in the previous section, the following browse products would be generated:

day: S1996121.L3_BRS_DAY

8-day: S19960171996024.L3_BRS_8D

month: S19960321996060.L3_BRS_MO

year: S19960011996366.L3_BRS_YR

8.3 Global Attributes

For global attributes that have constant values specific to this product type, the actual value is given.

8.3.1 Mission and Documentation

Product Name (character): the name of the product file (without path).

Title (character): "SeaWiFS Level-3 Browse Data".

Legend (character): "NASA/GSFC SeaWiFS Level-3 chlorophyll a browse data, day *DDD*, *YYYY*", where *DDD* and *YYYY* are the day and year portions of the **Start Time**.

Data Center (character): "NASA/GSFC SeaWiFS Data Processing Center".

Mission (character): "SeaStar SeaWiFS".

Mission Characteristics (character): "Nominal orbit: inclination = 98.2 (Sun-synchronous); node = 12 noon local (descending); eccentricity = <0.002; altitude = 705 km; ground speed = 6.75 km/sec".

Sensor (character): "Sea-viewing Wide Field-of-view Sensor (SeaWiFS)".

Sensor Name (character): "SeaWiFS".

Sensor Characteristics (character): "Number of bands = 8; number of active bands = 8; wavelengths per band (nm) = 412, 443, 490, 510, 555, 670, 765, 865; bits per pixel = 10; instantaneous field-of-view = 1.5835 mrad; pixels per scan = 1285; scan rate = 6/sec; sample rate = 7710/sec". Note: Pixels per scan, scan rate, and sample rate are given for the sensor; effective rates for GAC data are lower due to subsampling.

Replacement Flag (character): "ORIGINAL" if this is the first version of this product delivered to the DAAC; otherwise, it is set to the name of the product to be replaced (superseded) by the present product.

Software Name (character): "l3brsgen"; name of the software used to create this product.

Software Version (character): version of the software used to create this product.

Processing Time (character): local time of generation of this product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Input Files (character): the name of the SMI file (without path) from which the current product was created. This information is simply stored in the product as part of its processing history.

Processing Control (character): all input and processing control parameters used by the calling program to generate the product. Vertical bars or carriage return characters serve as parameter information delimiters. This information is simply stored in the product as part of its processing history.

Processing Log (character): important processing information, if any, such as errors, warnings, or summary data. Vertical bar or carriage return characters serve as new line delimiters. This information is simply stored in the product as part of its processing history.

8.3.2 Parent Product Information

The following attributes refer to the parent SMI product.

Parent Input Files (character): the name of the Level-3 binned data product (main file name without path) from which the parent product was created.

Product Type (character): "day", "8-day", "month", or "year".

Station Name (character): "Wallops Flight Facility".

Station Latitude (4-byte real): 37.9272.

Station Longitude (4-byte real): -75.4753.

Parent Number of Lines (4-byte integer): 2,048; number of points in the vertical (longitudinal) direction.

Parent Number of Columns (4-byte integer): 4,096; number of points in the horizontal (latitudinal) direction.

8.3.3 Data Time

The values of the following attributes are identical to those of the parent SMI product.

Period Start Year (2-byte integer): year of start of binning period (cf. **Start Year**).

Period Start Day (2-byte integer): GMT day-of-year of start of binning period (cf. **Start Day**).

Period End Year (2-byte integer): year of end of binning period (cf. **End Year**).

Period End Day (2-byte integer): GMT day-of-year of end of binning period (cf. **End Day**).

Start Time (character): data start GMT; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

End Time (character): data end GMT; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Start Year (2-byte integer): GMT year of data start.

Start Day (2-byte integer): GMT day-of-year of data start.

Start Millisec (4-byte integer): GMT milliseconds-of-day of data start.

End Year (2-byte integer): GMT year of data end.

End Day (2-byte integer): GMT day-of-year of data end.

End Millisec (4-byte integer): GMT milliseconds-of-day of data end.

Orbit (4-byte integer): number of the orbit crossing 180^{o} longitude closest to equator at the start.

Start Orbit (4-byte integer): number of the first orbit that may have contributed data.

End Orbit (4-byte integer): number of the last orbit that may have contributed data.

8.3.4 Scene Coordinates

The values of the following attributes are identical to those of the parent Level-3 SMI product.

Map Projection (character): "Equidistant Cylindrical".

Latitude Units (character): "degrees North"; units used for all latitude values in this product.

Longitude Units (character): "degrees East"; units used for all longitude values in this product.

Northernmost Latitude (4-byte real): 90.0.

Southernmost Latitude (4-byte real): -90.0.

Westernmost Longitude (4-byte real): -180.0.

Easternmost Longitude (4-byte real): 180.0.

8.3.5 Browse Image Information

Parameter (character): "Chlorophyll a concentration".

Measure (character): "Mean".

Units (character): "mg m^-3".

Start Column (4-byte integer): the first column of each line in the parent product used to create this product; values are 1-relative; normally, 1.

Column Subsampling Rate (4-byte integer): the column subsampling rate (starting with **Start Column**) used on parent product to create this product; normally, 8.

Number of Columns (4-byte integer): number of points in the horizontal (latitudinal) direction of **brs_data**; equals the integer portion of ((**Parent Number of Columns** - **Start Column**) / **Column Subsampling Rate**) + 1.

Start Line (4-byte integer): the first image line in the parent product used to create this product; values are 1-relative; normally, 1.

Line Subsampling Rate (4-byte integer): the image line subsampling rate (starting with **Start Line**) used on parent product to create this product; normally, 8.

Number of Lines (4-byte integer): number of points in the vertical (longitudinal) direction of **brs_data**; equals the integer portion of ((**Parent Number of Lines** - **Start Line**) / **Line Subsampling Rate**) + 1.

Scaling (character): "logarithmic".

Scaling Equation (character): "Base**((Slope*brs_data) + Intercept) = chlorophyll a".

Base (4-byte real): 10.0; used to convert the byte values (0-250) of **brs_data** into mg m^{-3} of chlorophyll *a*: **Base****((**Slope*****brs_data**) + **Intercept**) = chlorophyll *a*.

Slope (4-byte real): 0.015; used to convert the byte values (0-250) of **brs_data** into mg m^{-3} of chlorophyll *a*: **Base****((**Slope*****brs_data**) + **Intercept**) = chlorophyll *a*.

Intercept (4-byte real): -2.0; used to convert the byte values (0-250) of **brs_data** into mg m^{-3} of chlorophyll *a*: **Base****((**Slope*****brs_data**) + **Intercept**) = chlorophyll *a*.

8.4 Raster and Palette

brs_data (byte, array size **Number of Lines** x **Number of Columns**): raster image array of chlorophyll *a* data; may be converted into real values using **Base**, **Slope**, and **Intercept**; has an associated palette (byte, array size 3 x 256) of red, green, and blue weights for each of 256 (0 to 255, respectively) possible **brs_data** byte values. Byte values 251 to 255 in the raster image are reserved to indicate certain conditions (in the order of highest to lowest priority): 251 for image caption, 254 for political boundaries (including coastlines), 252 for geocoordinate grid, 253 for land, and 255 if the corresponding grid point in the parent SMI product is 255 (indicating no data).

8.5 Product Size

The main variables determining the size of Level-3 browse products (Table &) are the line and column subsampling rates. Assuming subsampling rates of 8, the **brs_data** array will be (2048x4096) / (8x8) = 128 KB. With about 15 KB of metadata and HDF overhead, a Level-3 browse product averages about 0.14 MB, for a daily volume (average of 1.16 products per day) of 0.16 MB and a mission volume of 0.29 GB.

9.0 Near Real-Time Ancillary Data Products

9.1 Introduction

The SeaWiFS Project creates products of the meteorological and ozone data, referred to as ancillary data, used during the Level-2 operational processing. These products are gridded, Equidistant Cylindrical images of, or derived from, data from other (non-SeaWiFS) sources. For Level-2 processing purposes, these data are treated as global "snapshots" at frequencies of at least once per day and as such are considered to be "near" real-time (NRT) data. (Note that the ozone data within a product are not snapshots but reflect the sequence of collection by the respective satellite.) See References & and & for more information regarding the generation of these products. Each product is contained in one physical HDF file.

As part of its quality control procedures, the Project may modify suspect values and fill missing values of NRT ancillary data grid points. An associated "Q/C" field is stored with each ancillary parameter image for recording for storing codes to indicate modifications to the original data. Definitions of the Q/C field codes are given in Table &.

9.2 Naming Convention

The form of the file names for NRT ancillary products is Syyyydddhh_ssssss.MET for meteorological parameters where S is for SeaWiFS, yyyydddhh are the concatenated digits for GMT year, day of the year, and hour, and ssss is the four- to six-character data source acronym. For ozone data from the Total Ozone Mapping Spectrometer (TOMS) aboard the Advanced Earth Observing Satellite (ADEOS) and the Earth Probe (EP) satellite, the file names have the same form as for meteorological data, namely, Syyyydddhh_ADTOMS and Syyyydddhh_EPTOMS.OZONE, respectively. For ozone data from the NOAA TIROS Operational Operational Vertical Sounder (TOVS), the form of the file names is Syyyydddhhdddhh_TOVS.OZONE where the yyyydddhhdddhh are the concatenated digits for data start GMT year, day of the year, and hour, and data end day of the year and hour.

Examples of file names are:

S199636606_NCEP.MET	Meteorological data from the National Center for Environmental Prediction model output for 0600 GMT, 31 December 1996.
S199612112_FNOC.MET	Meteorological data from the Fleet Numerical Oceanographic Center1 model output for 1200 GMT, 30 April 1996.
S199706112_ADTOMS.OZONE	ADEOS TOMS for 1200 GMT, 2 March 1997.
S199618512_EPTOMS.OZONE	EP TOMS for 1200 GMT, 3 July 1996.
S19953650500115_TOVS.OZONE	TOVS data for 31 December 1995, O500 GMT, to 1 January 1996, 1500 GMT.

Note that, for TOMS data, the hh part of the name corresponds only to the approximate (day) equatorial crossing time of the satellite and that data previous to those of the primary day may be used to fill in missing values. If data from source products other than the primary one (listed first in the

global attribute **Input Files**) are used, the global attributes **Start Time**, **End Time**, **Start Year**, **Start Day**, **Start Millisec**, **End Year**, **End Day**, and **End Millisec** will reflect the time range of the included data, and the global attribute **Input Files** will include the names of all source product files used.

For TOVS data, the products are gridded by the Project using data collected over a certain time range (about 35 hours). These original data are stored in files produced twice per day and therefore represent a rolling time window of data. The frequencies for other data are normally once per day at 1200 for ADEOS and EP TOMS ozone data, four times per day--every six hours starting at 0000--for NCEP meteorological data, and twice per day--every twelve hours starting at 0000--for FNOC meteorological data.

9.3 Global Attributes

For global attributes that have constant values specific to this product type, the actual value is given.

9.3.1 Mission and Documentation

Product Name (character): the name of the product file (without path).

Title (character): "SeaWiFS Near Real-Time Ancillary Data".

Data Center (character): "NASA/GSFC SeaWiFS Data Processing Center".

Mission (character): "SeaStar SeaWiFS".

Data Type (character): "Meteorological" or "Ozone".

Data Source (character): acronym name of data source. For **Data Type** = "Meteorological", possible values are "NCEP" and "FNOC"; for **Data Type** = "Ozone", possible values are "ADEOS TOMS", "EP TOMS", and "TOVS".

Data Source Desc (character): expanded name of data source. Possible values include "National Center for Environmental Prediction" for **Data Source** = "NCEP", "Fleet Numerical Oceanographic Center" for **Data Source** = "FNOC", "Advanced Earth Observing Satellite Total Ozone Mapping Spectrometer" for **Data Source** = "ADEOS TOMS", "Earth Probe Total Ozone Mapping Spectrometer" for **Data Source** = "EP TOMS", and "NOAA TIROS Operational Vertical Sounder" for **Data Source** = "TOVS".

Satellite Platform (character): "NOAA-11" for **Data Source** = "TOVS; "ADEOS" for **Data Source** = "ADEOS TOMS"; "TOMS-EP" for **Data Source** = "EP TOMS"; else, **Satellite Platform** is not included as a global attribute.

Replacement Flag (character): "ORIGINAL" if this is the first version of this product delivered to the DAAC; otherwise, it is set to the name of the product to be replaced (superseded) by the present product.

Software ID (character): identifies version of the operational software used to create this product.

Processing Time (character): local time of generation of this product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Input Files (character): the names of the non-HDF source files (without path) from which the current product was created. This information is simply stored in the product as part of its processing history.

Processing Control (character): all input and processing control parameters used by the calling program to generate the product. Vertical bars or carriage return characters serve as parameter information delimiters. This information is simply stored in the product as part of its processing history.

Processing Log (character): important processing information, if any, such as errors, warnings, or summary data. Vertical bar or carriage return characters serve as new line delimiters. This information is simply stored in the product as part of its processing history.

QC Comments (charater): comments regarding quality control of this product by the SeaWiFS Project. This information is simply stored in the product as part of its processing history.

9.3.2 Data Time

Start Time (character): concatenated digits for GMT year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF; represents data start time for **Data Type** = "Ozone"; else, represents data time.

End Time (character): concatenated digits for GMT year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF; represents data end time for **Data Type** = "Ozone"; else, same as **Start Time**.

Start Year (2-byte integer): GMT year of data start for **Data Type** = "Ozone"; else, data GMT year.

Start Day (2-byte integer): GMT day-of-year of data start for **Data Type** = "Ozone"; else, data GMT day-of-year.

Start Millisec (4-byte integer): GMT milliseconds-of-day of data start for **Data Type** = "Ozone"; else, data GMT milliseconds-of-day.

End Year (2-byte integer): GMT year of data end for **Data Type** = "Ozone"; else, same as **Start Year**.

End Day (2-byte integer): GMT day-of-year of data end for **Data Type** = "Ozone"; else, same as **Start Day**.

End Millisec (4-byte integer): GMT milliseconds-of-day of data end for **Data Type** = "Ozone"; else, same as **Start Millisec**.

Node Crossing Time (character): For **Data Source** = "ADEOS TOMS" or "EP TOMS", local equatorial crossing time of day-side node as concatenated digits for year, day-of-year, hours, minutes,

seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF; else, **Node Crossing Time** is not included as a global attribute.

9.3.3 Data Description

Map Projection (character): "Equidistant Cylindrical".

Latitude Units (character): "degrees North"; units used for all latitude values in this product.

Longitude Units (character): "degrees East"; units used for all longitude values in this product.

Northernmost Latitude (4-byte real): 90.0.

Southernmost Latitude (4-byte real): -90.0.

Westernmost Longitude (4-byte real): -180.0.

Easternmost Longitude (4-byte real): 180.0.

Latitude Step (4-byte real): latitudinal distance between rows; 1.0.

Longitude Step (4-byte real): longitudinal distance between columns; 1.0 for **Data Type** = "Meteorological" and 1.25 for **Data Type** = "Ozone".

SW Point Latitude (4-byte real): latitude of data point for southwesternmost grid cell to indicate location of data center within each grid cell; -90.0 for **Data Type** = "Meteorological" and -89.5 for **Data Type** = "Ozone".

SW Point Longitude (4-byte real): longitude of data point for southwesternmost grid cell to indicate location of data center within each grid cell; -180.0 for **Data Type** = "Meteorological" and -179.375 for **Data Type** = "Ozone".

Number of Rows (4-byte integer): number of points in the vertical (longitudinal) direction; 181 for **Data Type** = "Meteorological" and 180 for **Data Type** = "Ozone".

Number of Columns (4-byte integer): number of points in the horizontal (latitudinal) direction; 360 for **Data Type** = "Meteorological" and 288 for **Data Type** = "Ozone".

Temporal Resolution (4-byte integer): temporal resolution in hours; 6 for **Data Source** = "NCEP"; 12 for **Data Source** = "FNOC" or "TOVS" (for TOVS, the value is approximate); and 24 for **Data Source** = "ADEOS TOMS" or "EP TOMS".

Points Modified (4-byte integer): total number of grid points for which any of the geophysical data values (if more than one field) have been modified from the primary input product (first product listed in the global attribute **Input Files**), not including the TOVS data (**Data Source** = TOVS) changed as a result of the gridding process; equals the count of values not equal to zero in all _**QC** SDSs combined via a Boolean OR operation.

9.4 Vgroup Geophysical Data

The Vgroup "Geophysical Data" contains the following SDS data objects when **Data Type** = "Meteorological" (see Figure &). Attributes of the SDSs are shown in **bold**. The first point in each array is the northwesternmost point of each grid.

z_wind (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Zonal wind at 10 m"; **units** = "m sec^-1".

z_wind_QC (byte, array size **Number of Lines** x **Number of Columns**): **long_name** = "Zonal wind at 10 m Q/C flag"; set to a code value (Table &) if the corresponding **z_wind** point has been modified from value obtained from the primary data product (listed first in **Input Files**); else, =0.

m_wind (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Meridional wind at 10 m"; **units** = "m sec^-1".

m_wind_QC (byte, array size **Number of Lines** x **Number of Columns**): **long_name** = "Meridional wind at 10 m Q/C flag"; set to a code value (Table &) if the corresponding **m_wind** point has been modified from value obtained from the primary data product (listed first in **Input Files**); else, =0.

press (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Atmospheric pressure at mean sea level"; **units** = "millibars".

press_QC (byte, array size **Number of Lines** x **Number of Columns**): **long_name** = "Atmospheric pressure at mean sea level Q/C flag"; set to a code value (Table &) if the corresponding **press** point has been modified from value obtained from the primary data product (listed first in **Input Files**); else, =0.

rel_hum (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Relative humidity at 1000 mb"; **units** = "percent".

rel_hum_QC (byte, array size **Number of Lines** x **Number of Columns**): **long_name** = "Relative humidity at 1000 mb Q/C flag".

p_water (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Precipitable water"; **units** = "kg m^-2".

p_water_QC (byte, array size **Number of Lines** x **Number of Columns**): **long_name** = "Precipitable water Q/C flag"; set to a code value (Table &) if the corresponding **p_water** point has been modified from value obtained from the primary data product (listed first in **Input Files**); else, =0.

The Vgroup "Geophysical Data" contains the following SDS data objects when **Data Type** = "Ozone". Attributes of the SDSs are shown in **bold**. The first point in each array is the northwesternmost point of each grid.

ozone (2-byte integer, array size **Number of Lines** x **Number of Columns**): **long_name** = "Total ozone"; **units** = "Dobson units".

ozone_QC (byte, array size **Number of Lines** x **Number of Columns**): **long_name** = "Total ozone Q/C flag"; set to a code value (Table &) if the corresponding **ozone** point has been modified from the primary data product (listed first in **Input Files**); else, =0. Note that TOVS data (**Data Source** = TOVS) changed as a result of the gridding process do not have their Q/C flag changed from 0.

9.5 Product Size

NRT ancillary data products are of almost constant size since their main data objects, the Geophysical Data SDSs are constant in size. For meteorological data products, each meteorological parameter and its Q/C flag field require 5 bytes per grid point. For five parameters, the volume of these SDSs is 5 x 5 x 181 x 360 = 1,591 KB, or 1.6 MB with metadata and overhead. Assuming four products per day (**Data Source** = "NCEP"), the daily volume is 6.4 MB and the mission volume is 11.4 GB.

For ozone data products, each ozone value and its Q/C flag field require 3 bytes per grid point for a total of 3 x 288 x 180 = 152 KB, or 161 KB with metadata and overhead. With one product per day, the mission volume is 0.28 GB.

Table 2. Code byte values (0 to 255) for Q/C flag SDS fields indicating modifications made to corresponding grid points in the associated geophysical data SDS fields. Values not listed are not used.

Q/C Code	Modification
0	no change (except gridding of TOVS data)
1	unspecified change during interactive Q/C
9	value is an average of values from primary input product (first file listed in Input Files) and nearest-in-time available source product (also listed in Input Files)
10	value from primary input product (first file listed in Input Files) was missing; value used is from earlier source product (also listed in Input Files)
11	value used is that of nearest grid point whose Q/C code is 0

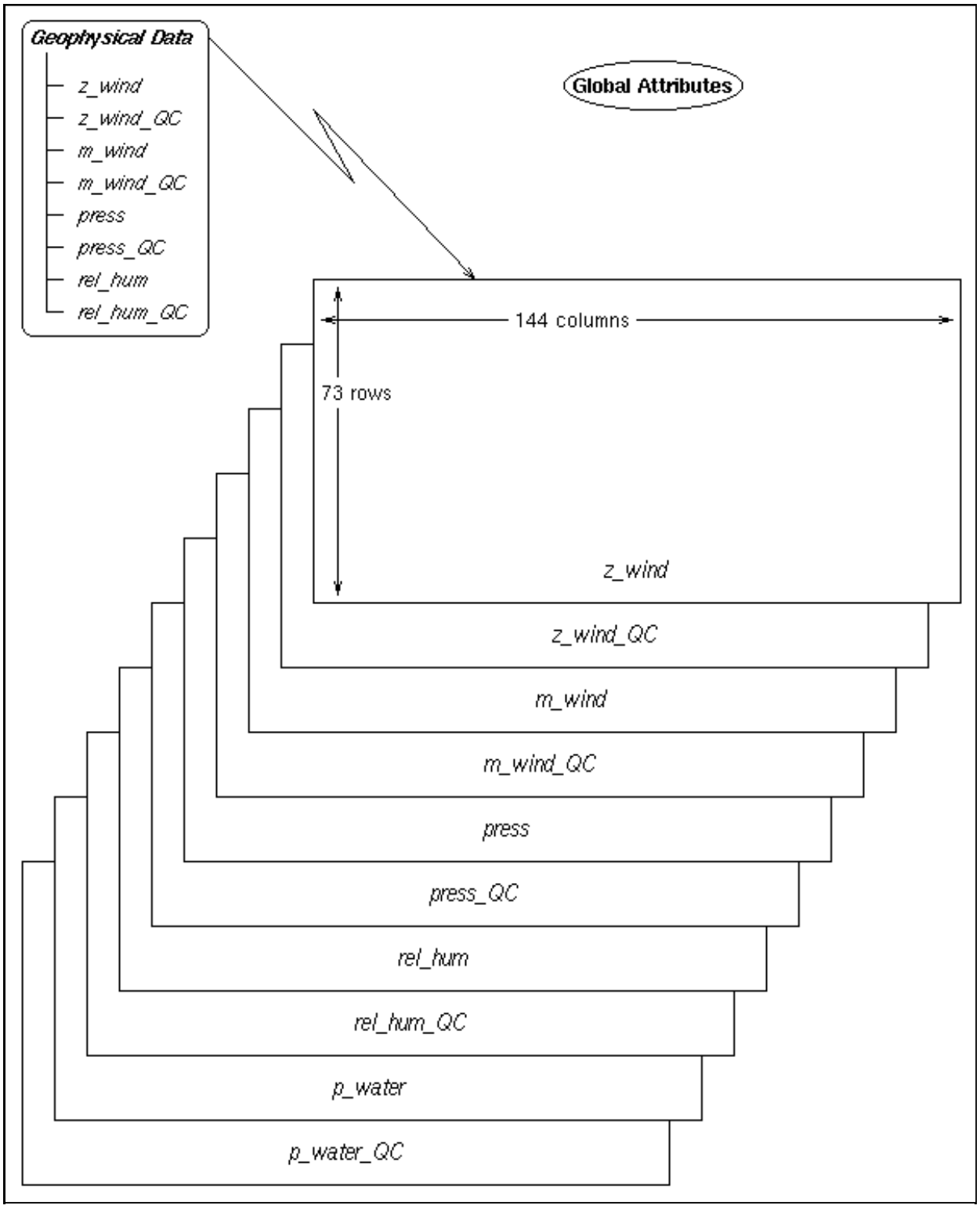

Figure 3. Data objects of the near-real time meteorological ancillary data product showing global attributes (oval), Vgroups (curved-corner rectangles), and the meteorological, and associated Q/C, data SDSs (rectangles).

10.0 Climatological Ancillary Data Products

10.1 Introduction

Climatologies of the ancillary data required for Level-2 processing have been created by the SeaWiFS Project (Reference &). These climatologies can be used by the Level-2 processing software in lieu of NRT data when the NRT data are unavailable or deemed to be of poor quality.

Two climatological products, each, a single HDF file, are used--one for five meteorological parameters and the other for ozone. For each of these six parameters, long-term monthly means were calculated using data from other agencies. The means, along with the associated standard deviations and number of observations, are stored as gridded, Equidistant Cylindrical images.

10.2 Naming Convention

The form of the file names for the climatological ancillary products is Syyyyyyyy_ssss.MET for meteorological parameters and Syyyyyyyy_ssss.OZONE for ozone data, where S is for SeaWiFS, yyyyyyyy are the concatenated digits for the start and end years and ssss is the data source acronym.

Examples of file names are:

S19461993_COADS_GEOS1.MET	Climatology of meteorological data from 1946 to 1990 from the Comprehensive Ocean-Atmosphere Data Set for winds, pressure, and humidity and from 1980 to 1993 from the GEOS-1 Multiyear Assimilation for precipitable water.
S19891991_TOMS.MET	Climatology of ozone data from 1989 to 1991 from the Nimbus-7 Total Ozone Mapping Spectrometer.

10.3 Global Attributes

For global attributes that have constant values specific to this product type, the actual value is given.

10.3.1 Mission and Documentation

Product Name (character): the name of the product file (without path).

Title (character): "SeaWiFS Climatological Ancillary Data".

Data Center (character): "NASA/GSFC SeaWiFS Data Processing Center".

Mission (character): "SeaStar SeaWiFS".

Data Type (character): "Meteorological" or "Ozone".

Data Source (character): acronym name of data source. "COADS and GEOS-1" for **Data Type** = "Meteorological" and "Nimbus TOMS" for **Data Type** = "Ozone".

Data Source Desc (character): expanded name of data source. "Comprehensive Ocean-Atmosphere Data Set and National Center for Environmental Prediction (u_wind, v_wind, press, rel_hum; from January, 1946, to December, 1990) and GEOS-1 Multiyear Assimilation (p_water; from March, 1980, to November, 1993)" for **Data Source** = "COADS and GEOS-1" and "Nimbus Total Ozone Mapping Spectrometer" for **Data Source** = "Nimbus TOMS".

Satellite Platform (character): "Nimbus 7" for **Data Source** = "Nimbus TOMS; else, **Satellite Platform** is not included as a global attribute.

Replacement Flag (character): "S19461990_COADS.MET", the name of the product to be replaced (superseded) by the present product, for **Data Type** = "Meteorological" and "ORIGINAL", indicating that this is the first version delivered to the DAAC, for **Data Type** = "Ozone".

Software ID (character): identifies version of the operational software used to create this product.

Processing Time (character): local time of generation of this product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

QC Comments (charater): comments regarding quality control of this product by the SeaWiFS Project. This information is simply stored in the product as part of its processing history.

10.3.2 Data Description

Start Year (2-byte integer): Data start year.

Start Month (2-byte integer): Data start month.

End Year (2-byte integer): Data end year.

End Month (2-byte integer): Data end month.

Map Projection (character): "Equidistant Cylindrical".

Latitude Units (character): "degrees North"; units used for all latitude values in this product.

Longitude Units (character): "degrees East"; units used for all longitude values in this product.

Northernmost Latitude (4-byte real): 90.0.

Southernmost Latitude (4-byte real): -90.0.

Westernmost Longitude (4-byte real): -180.0.

Easternmost Longitude (4-byte real): 180.0.

Latitude Step (4-byte real): latitudinal distance between rows; 2.0 for **Data Type** = "Meteorological" and 1.0 for **Data Type** = "Ozone".

Longitude Step (4-byte real): longitudinal distance between columns; 2.5 for **Data Type** = "Meteorological" and 1.25 for **Data Type** = "Ozone".

SW Point Latitude (4-byte real): latitude of data point for southwesternmost grid cell to indicate location of data center within each grid cell; -90.0 for **Data Type** = "Meteorological" and -89.5 for **Data Type** = "Ozone".

SW Point Longitude (4-byte real): longitude of data point for southwesternmost grid cell to indicate location of data center within each grid cell; -180.0 for **Data Type** = "Meteorological" and -179.375 for **Data Type** = "Ozone".

Number of Rows (4-byte integer): number of points in the vertical (longitudinal) direction; 91 for **Data Type** = "Meteorological" and 180 for **Data Type** = "Ozone".

Number of Columns (4-byte integer): number of points in the horizontal (latitudinal) direction; 144 for **Data Type** = "Meteorological" and 288 for **Data Type** = "Ozone".

10.4 Vgroups

There are twelve Vgroups in the climatological ancillary products, one for each month: January, February, March, April, May, June, July, August, September, October, November, and December. Each of these Vgroups contains the SDSs described in the following subsections.

10.4.1 Meteorological Data

For **Data Type** = "Meteorological", each of the monthly Vgroups contains the folowing fifteen SDSs (see Figure &). Attributes of the SDSs are shown in **bold**. The first point in each array is the northwesternmost point of each grid.

z_wind_mean (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Zonal wind at 1000 mb, monthly mean"; **units** = "m sec^-1".

z_wind_std_dev (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Zonal wind at 1000 mb, standard deviation"; **units** = "m sec^-1".

z_wind_obs (2-byte integer, array size **Number of Lines** x **Number of Columns**): **long_name** = "Zonal wind at 1000 mb, number of observations"; **units** = "number of observations".

m_wind_mean (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Meridional wind at 1000 mb, monthly mean"; **units** = "m sec^-1".

m_wind_std_dev (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Meridional wind at 1000 mb, standard deviation"; **units** = "m sec^-1".

m_wind_obs (2-byte integer, array size **Number of Lines** x **Number of Columns**): **long_name** = "Meridional wind at 1000 mb, number of observations"; **units** = "number of observations".

press_mean (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Atmospheric pressure at mean sea level, monthly mean"; **units** = "millibars".

press_std_dev (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Atmospheric pressure at mean sea level, standard deviation"; **units** = "millibars".

press_obs (2-byte integer, array size **Number of Lines** x **Number of Columns**): **long_name** = "Atmospheric pressure at mean sea level, number of observations"; **units** = "number of observations".

rel_hum_mean (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Relative humidity at 1000 mb, monthly mean"; **units** = "percent".

rel_hum_std_dev (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Relative humidity at 1000 mb, standard deviation"; **units** = "percent".

rel_hum_obs (2-byte integer, array size **Number of Lines** x **Number of Columns**): **long_name** = "Relative humidity at 1000 mb, number of observations"; **units** = "number of observations".

p_water_mean (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Precipitable water, monthly mean"; **units** = "kg m^-2".

p_water_std_dev (4-byte real, array size **Number of Lines** x **Number of Columns**): **long_name** = "Precipitable water, standard deviation"; **units** = "kg m^-2".

p_water_obs (2-byte integer, array size **Number of Lines** x **Number of Columns**): **long_name** = "Precipitable water, number of observations"; **units** = "number of observations".

10.4.2 Ozone Data

For **Data Type** = "Ozone", each of the monthly Vgroups contains the folowing three SDSs. Attributes of the SDSs are shown in **bold**. The first point in each array is the northwesternmost point of each grid.

ozone_mean (2-byte integer, array size **Number of Lines** x **Number of Columns**): **long_name** = "Total ozone, monthly mean"; **units** = "Dobson units".

ozone_std_dev (2-byte integer, array size **Number of Lines** x **Number of Columns**): **long_name** = "Total ozone, standard deviation" **units** = "Dobson units".

ozone_obs (2-byte integer, array size **Number of Lines** x **Number of Columns**): **long_name** = "Total ozone, number of observations"; **units** = "number of observations".

10.5 Product Size

Climatological ancillary data products are of almost constant size since their main data objects, the SDSs in the monthly Vgroups are constant in size. For the meteorological climatologies, the mean, standard deviation, and number of observations of each meteorological parameter require 10 bytes per grid point. For five parameters in 12 monthly Vgroups, the volume of these SDSs is 10 x 5 x 12 x 144 x 91 = 7,678 KB, or 7.8 MB with metadata and overhead.

For the ozone climatology, the mean, standard deviation, and number of observations require 6 bytes per grid point for a total of 6 x 12 x 288 x 180 = 3,645 KB, or 3.6 KB with metadata and overhead.

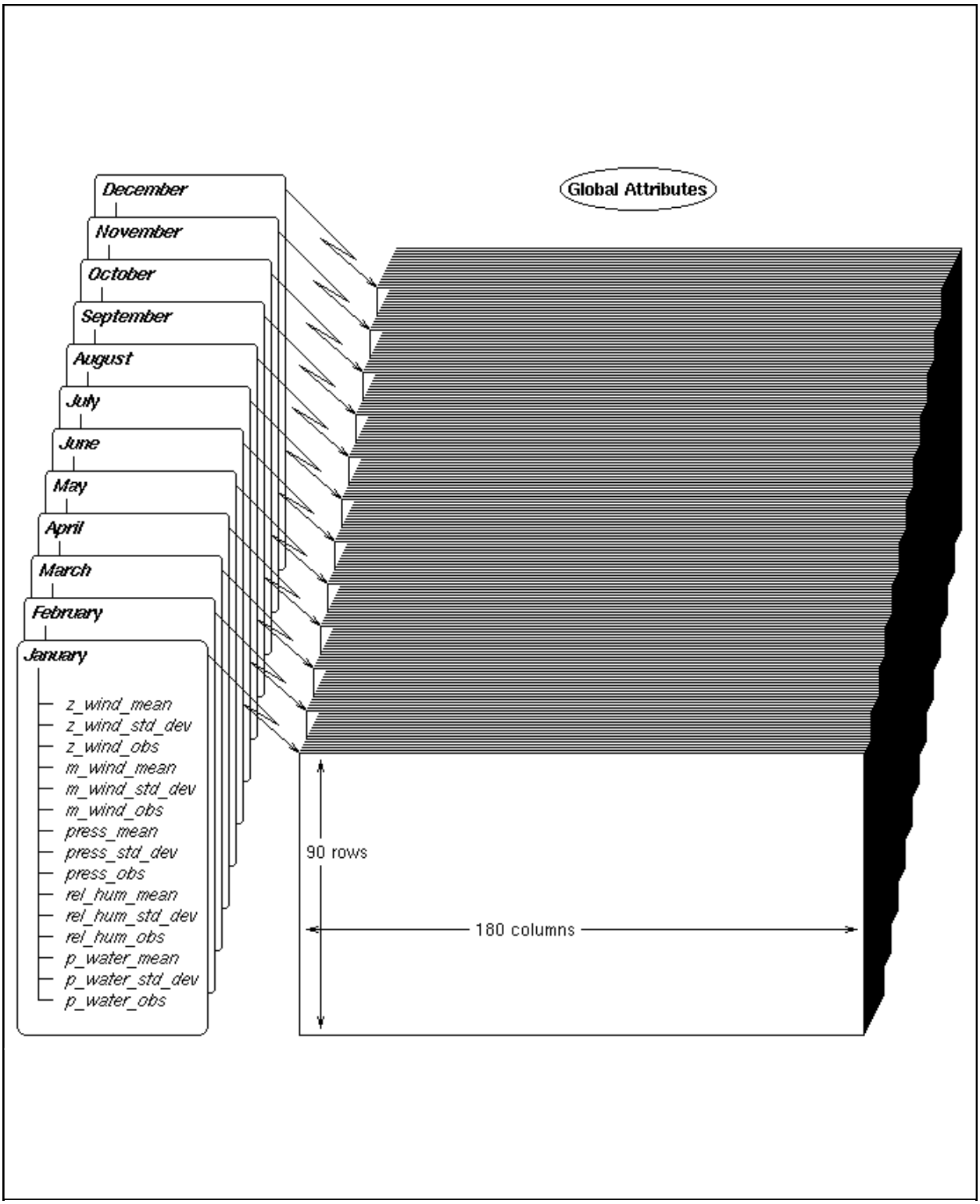

Figure 4. Data objects of the climatological product for meteorological ancillary data showing global attributes (oval), Vgroups (curved-corner rectangles), and the meteorological data SDSs (rectangles).

11.0 Sensor Calibration Table

11.1 Introduction

The sensor calibration table (see Figure &) is comprised of a set of parameters required for applying the sensor calibration to raw (Level-1A) data. See Reference & for a description of the algorithm for applying the sensor calibration. The table is stored as one physical HDF file that is available as a SeaWiFS product.

The calibration table includes parameters that will not be changed and parameters that may be updated. Updates are performed by the SeaWiFS Project and result in the appending of data to the file's contents--no data are deleted. Whenever it is updated, a new version of the file is made available as a product. Results of vicarious calibration studies can indicate if updates are needed to improve previous calibration parameter values or to account for changes in sensor characteristics.

11.2 Naming Convention

The sensor calibration table file name is:

SEAWIFS_SENSOR_CAL.TBL

11.3 Global Attributes

For global attributes that have constant values specific to this product type, the actual value is given.

Product Name (character): "SEAWIFS_SENSOR_CAL.TBL".

Title (character): "Sensor Calibration Table".

Data Center (character): "NASA/GSFC SeaWiFS Data Processing Center".

Mission (character): "SeaStar SeaWiFS".

Mission Characteristics (character): "Nominal orbit: inclination = 98.2 (Sun-synchronous); node = 12 noon local (descending); eccentricity = <0.002; altitude = 705 km; ground speed = 6.75 km/sec".

Sensor (character): "Sea-viewing Wide Field-of-view Sensor (SeaWiFS)".

Sensor Characteristics (character): "Number of bands = 8; number of active bands = 8; wavelengths per band (nm) = 412, 443, 490, 510, 555, 670, 765, 865; bits per pixel = 10; instantaneous field-of-view = 1.5835 mrad; pixels per scan = 1285; scan rate = 6/sec; sample rate = 7710/sec". Note: Pixels per scan, scan rate, and sample rate are given for the sensor; effective rates for GAC data are lower due to subsampling.

Replacement Flag (character): "SEAWIFS_SENSOR_CAL.TBL"--always set to its own name since it always supersedes the previous version of the sensor calibration table.

Reference Year (2-byte integer): 1997; the year of the calibration reference time (time of transfer of the SeaWiFS calibration to orbit).

Reference Day (2-byte integer): 64; the day of year of the calibration reference time (time of transfer of the SeaWiFS calibration to orbit).

Reference Minute (2-byte integer): 720; the minute of day of the calibration reference time (time of transfer of the SeaWiFS calibration to orbit).

11.4 Parameters Containing Constants

The following SDS arrays contain values that are not updated during the mission. Attributes of the SDSs are shown in **bold**

TDI_list (2-byte integer, array size 256 x 4): **long_name** = "Time delay and integration (TDI) values"; dimensions are number of detector combinations x detectors.

temps (4-byte real, array size 256 x 8): **long_name** = "Temperature correction coefficients"; dimensions are digitized temperature x bands.

scan_mod (4-byte real, array size 2 x 1285): **long_name** = "Scan modulation correction factors"; dimensions are even/odd band number x pixels.

11.5 Parameters That May Be Updated

When the calibration is "updated," a new entry is appended to the end of each of the updatable parameters. Thus, an entry consists of the values entered for all of the parameters in this section as part of an update. Each entry is associated with a time range that is specified as part of that entry. A time range defines a period of time corresponding to SeaWiFS data for which that entry's calibration parameter values apply.

A newly entered time period will supersede part or all of one or more previously entered time periods. Only one period at a time is allowed to have the end limit be open to indicate that the period includes the most recent satellite data.

Eight Vgroups, one for each band, are of class **Calibration**: **Band1**, **Band2**, **Band3**, **Band4**, **Band5**, **Band6**, **Band7**, and **Band8**. Each of these Vgroups contain two Vdatas with fields to which data may be appended--Vdata **BxSlopes** and Vdata **BxParms**, where, for both Vdatas, x = 1 to 8, corresponding to the index within the corresponding Vgroup name (*i.e.*, the band number). There is an additional Vdata, **Time**, of class **Calibration** that contains fields to specify time information for each entry. Although there is only one **Time** Vdata, it is linked to each of the **Bandx** Vgroups.

11.5.1 Vdata BxSlopes

Each **BxSlopes** (x = 1 to 8) Vdata contains the following fields, the number of whose values corresponds to the number of entries:

g1d1 (4-byte real): radiance-to-counts slope for gain 1 and detector 1.

g1d2 (4-byte real): radiance-to-counts slope for gain 1 and detector 2.

g1d3 (4-byte real): radiance-to-counts slope for gain 1 and detector 3.

g1d4 (4-byte real): radiance-to-counts slope for gain 1 and detector 4.

g2d1 (4-byte real): radiance-to-counts slope for gain 2 and detector 1.

g2d2 (4-byte real): radiance-to-counts slope for gain 2 and detector 2.

g2d3 (4-byte real): radiance-to-counts slope for gain 2 and detector 3.

g2d4 (4-byte real): radiance-to-counts slope for gain 2 and detector 4.

g3d1 (4-byte real): radiance-to-counts slope for gain 3 and detector 1.

g3d2 (4-byte real): radiance-to-counts slope for gain 3 and detector 2.

g3d3 (4-byte real): radiance-to-counts slope for gain 3 and detector 3.

g3d4 (4-byte real): radiance-to-counts slope for gain 3 and detector 4.

g4d1 (4-byte real): radiance-to-counts slope for gain 4 and detector 1.

g4d2 (4-byte real): radiance-to-counts slope for gain 4 and detector 2.

g4d3 (4-byte real): radiance-to-counts slope for gain 4 and detector 3.

g4d4 (4-byte real): radiance-to-counts slope for gain 4 and detector 4.

11.5.2 Vdata BxParms

Each **BxParms** (x = 1 to 8) Vdata contains the following fields, the number of whose values corresponds to the number of entries:

offs1 (2-byte integer): zero-offset counts for detector 1.

offs2 (2-byte integer): zero-offset counts for detector 2.

offs3 (2-byte integer): zero-offset counts for detector 3.

offs4 (2-byte integer): zero-offset counts for detector 4.

t_const (8-byte real): time-dependent correction constant term.

t_linear (8-byte real): time-dependent correction linear coefficient.

t_quadratic (8-byte real): time-dependent correction quadratic coefficient.

cal_offs (4-byte real): calibration system offset.

mirror1 (4-byte real): mirror correction factor for side 1.

mirror2 (4-byte real): mirror correction factor for side 2.

11.5.3 Vdata Time

The **Time** Vdata data object occurs once in the file but is linked to each **Bandx** (x = 1 to 8) Vgroup. It contains the following fields, the number of whose values corresponds to the number of entries:

entry_year (2-byte integer): the year (4 digits) the entry is made.

entry_day (2-byte integer): the day-of-year the entry is made.

syear (2-byte integer): start year (4 digits) of the time period for which the corresponding calibration entry applies.

sday (2-byte integer): start day-of-year of the time period for which the corresponding calibration entry applies.

smsec (4-byte integer): start time-of-day (milliseconds) of the time period for which the corresponding calibration entry applies.

eyear (2-byte integer): end year (4 digits) of the time period for which the corresponding calibration entry applies; if 0, indicates that no end to the time period of the entry is specified and that the entry applies up to the most recent satellite data.

eday (2-byte integer): end day-of-year of the time period for which the corresponding calibration entry applies; if 0, indicates that no end to the time period of the entry is specified and that the entry applies up to the most recent satellite data.

emsec (4-byte integer): end time-of-day (milliseconds) of the time period for which the corresponding calibration entry applies; if 0, indicates that no end to the time period of the entry is specified and that the entry applies up to the most recent satellite data.

11.6 Product Size

The size of the sensor calibration table file is 0.91 MB (Table &). This size will remain essentially constant through the mission since it includes empty records for up to 150 updates.

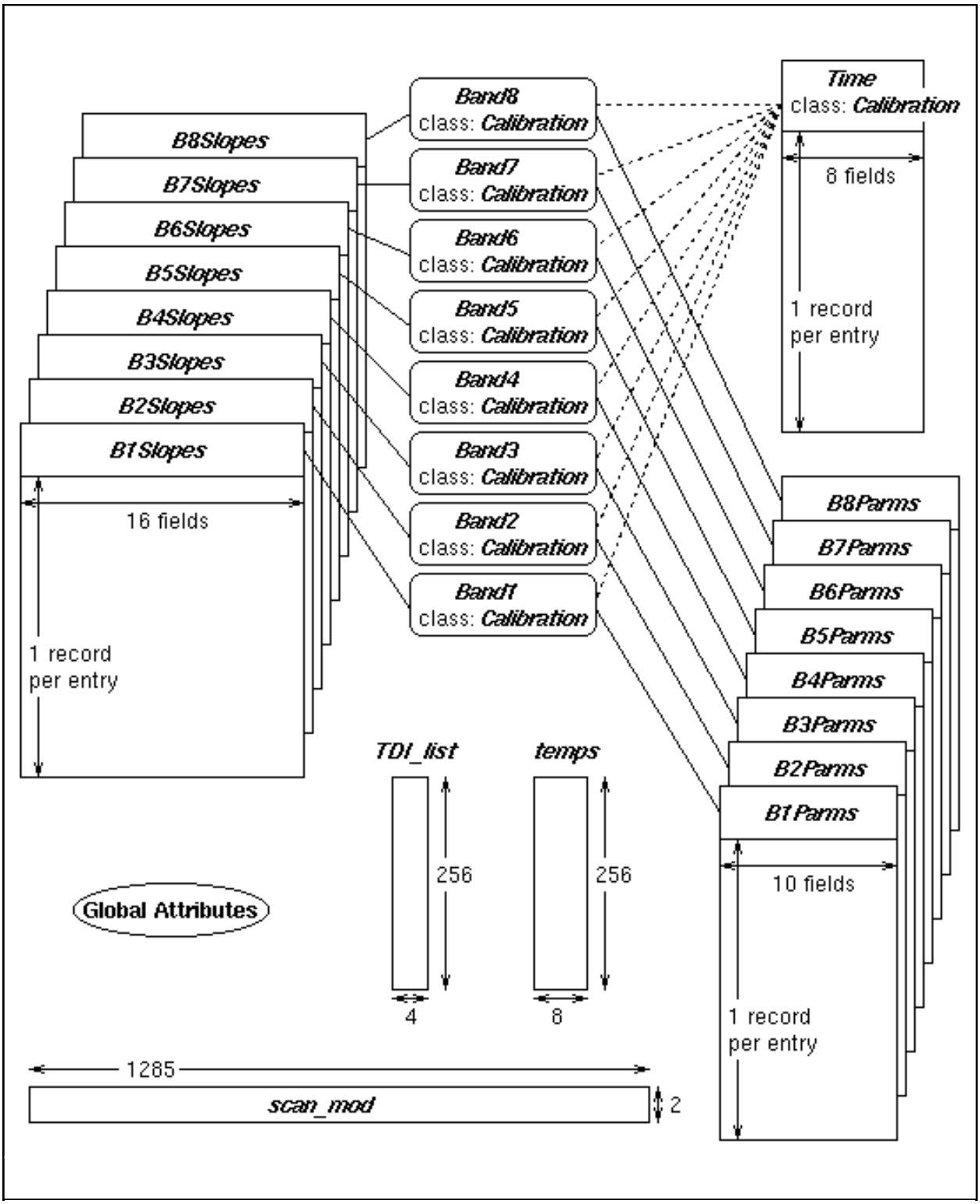

Figure 5. Data objects of the sensor calibration table showing global attributes (oval), SDSs of parameter constants (simple rectangles), and Vgroups (curved-corner rectangles) with their Vdatas (tables) for updatable parameters.